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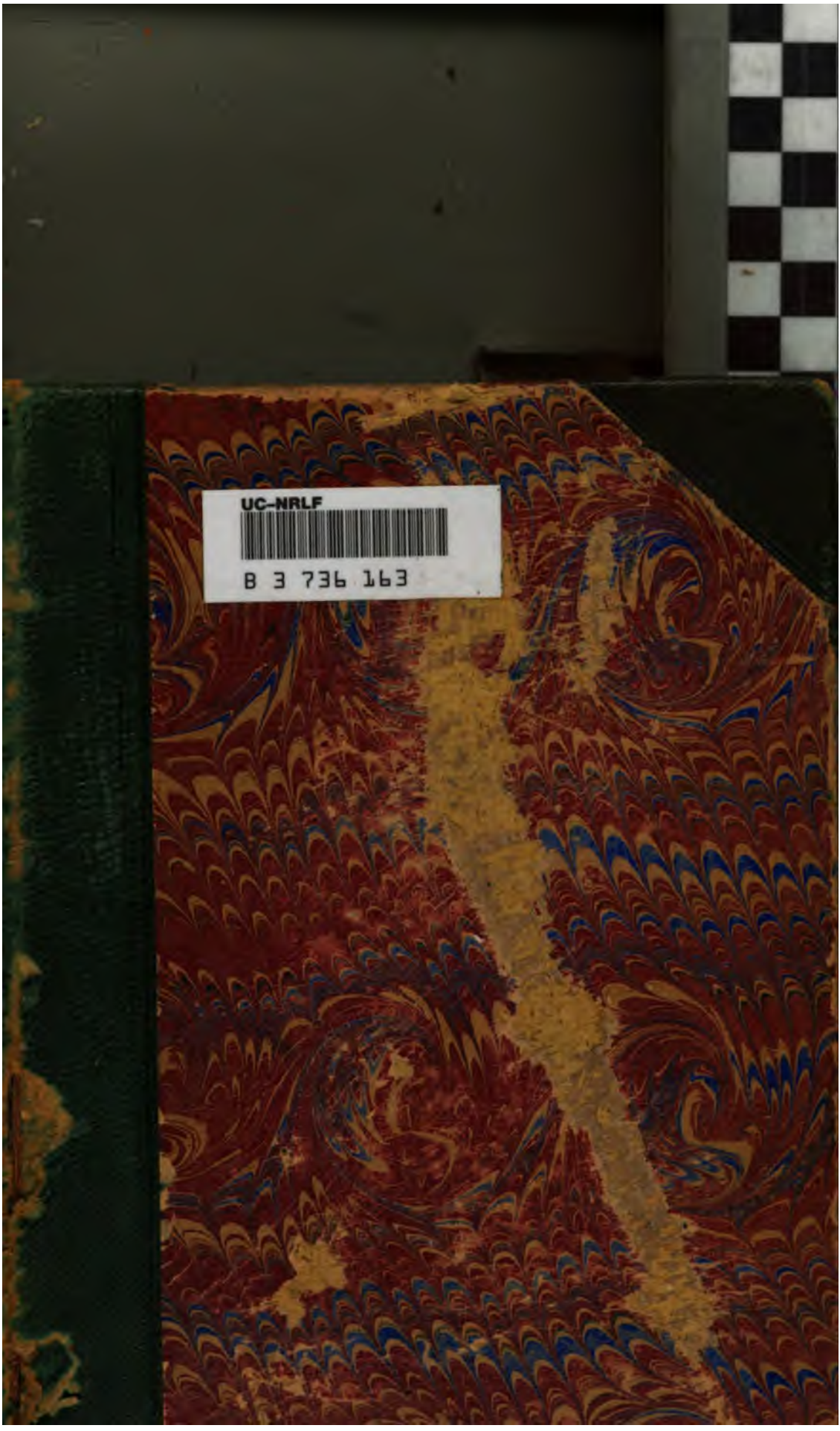
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# REPORT

OF THE

# THIRTY-SIXTH MEETING

OF THE

# BRITISH ASSOCIATION

FOR THE

# ADVANCEMENT OF SCIENCE;

HELD AT

NOTTINGHAM IN AUGUST 1866.

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# OBJECTS AND RULES

OF

# THE ASSOCIATION.

REESE LIBRARY OF THE UNIVERSITY OF CALIFORNIA

## OBJECTS.

The Association contemplates no interference with the ground occupied by other institutions. Its objects are,—To give a stronger impulse and a more systematic direction to scientific inquiry,—to promote the intercourse of those who cultivate Science in different parts of the British Empire, with one another, and with foreign philosophers,—to obtain a more general attention to the objects of Science, and a removal of any disadvantages of a public kind which impede its progress.

## RULES.

### ADMISSION OF MEMBERS AND ASSOCIATES.

All persons who have attended the first Meeting shall be entitled to become Members of the Association, upon subscribing an obligation to conform to its Rules.

The Fellows and Members of Chartered Literary and Philosophical Societies publishing Transactions, in the British Empire, shall be entitled, in like manner, to become Members of the Association.

The Officers and Members of the Councils, or Managing Committees, of Philosophical Institutions, shall be entitled, in like manner, to become Members of the Association.

All Members of a Philosophical Institution recommended by its Council or Managing Committee, shall be entitled, in like manner, to become Members of the Association.

Persons not belonging to such Institutions shall be elected by the General Committee or Council, to become Life Members of the Association, Annual Subscribers, or Associates for the year, subject to the approval of a General Meeting.

### COMPOSITIONS, SUBSCRIPTIONS, AND PRIVILEGES.

Life Members shall pay, on admission, the sum of Ten Pounds. They shall receive *gratuitously* the Reports of the Association which may be published after the date of such payment. They are eligible to all the offices of the Association.

Annual Subscribers shall pay, on admission, the sum of Two Pounds, and in each following year the sum of One Pound. They shall receive *gratuitously* the Reports of the Association for the year of their admission and for the years in which they continue to pay *without intermission* their Annual Subscription. By omitting to pay this Subscription in any particular year, Members of this class (Annual Subscribers) *lose for that and all future years* the privilege of receiving the volumes of the Association *gratis*: but they may resume their Membership and other privileges at any subsequent Meeting of the Association, paying on each such occasion the sum of One Pound. They are eligible to all the Offices of the Association.

Associates for the year shall pay on admission the sum of One Pound. They shall not receive *gratuitously* the Reports of the Association, nor be eligible to serve on Committees, or to hold any office.

The Association consists of the following classes:—

1. Life Members admitted from 1831 to 1845 inclusive, who have paid on admission Five Pounds as a composition.

2. Life Members who in 1846, or in subsequent years, have paid on admission Ten Pounds as a composition.

3. Annual Members admitted from 1831 to 1839 inclusive, subject to the payment of One Pound annually. [May resume their Membership after intermission of Annual Payment.]

4. Annual Members admitted in any year since 1839, subject to the payment of Two Pounds for the first year, and One Pound in each following year. [May resume their Membership after intermission of Annual Payment.]

5. Associates for the year, subject to the payment of One Pound.

6. Corresponding Members nominated by the Council.

And the Members and Associates will be entitled to receive the annual volume of Reports, *gratis*, or to *purchase* it at reduced (or Members') price, according to the following specification, viz.:—

1. *Gratis.*—Old Life Members who have paid Five Pounds as a composition for Annual Payments, and previous to 1845 a further sum of Two Pounds as a Book Subscription, or, since 1845, a further sum of Five Pounds.

   New Life Members who have paid Ten Pounds as a composition.

   Annual Members who have not intermitted their Annual Subscription.

2. *At reduced or Members' Prices*, viz. two-thirds of the Publication Price.—Old Life Members who have paid Five Pounds as a composition for Annual Payments, but no further sum as a Book Subscription.

   Annual Members who have intermitted their Annual Subscription.

   Associates for the year. [Privilege confined to the volume for that year only.]

3. Members may purchase (for the purpose of completing their sets) any of the first seventeen volumes of Transactions of the Association, *and of which more than* 100 *copies remain*, at one-third of the Publication Price. Application to be made (by letter) to Messrs. Taylor & Francis, Red Lion Court, Fleet St., London.

Subscriptions shall be received by the Treasurer or Secretaries.

### MEETINGS.

The Association shall meet annually, for one week, or longer. The place of each Meeting shall be appointed by the General Committee at the previous Meeting; and the Arrangements for it shall be entrusted to the Officers of the Association.

### GENERAL COMMITTEE.

The General Committee shall sit during the week of the Meeting, or longer, to transact the business of the Association. It shall consist of the following persons:—

1. Presidents and Officers for the present and preceding years, with authors of Reports in the Transactions of the Association.

2. Members who have communicated any Paper to a Philosophical Society, which has been printed in its Transactions, and which relates to such subjects as are taken into consideration at the Sectional Meetings of the Association.

3. Office-bearers for the time being, or Delegates, altogether not exceeding three in number, from any Philosophical Society publishing Transactions.

4. Office-bearers for the time being, or Delegates, not exceeding three, from Philosophical Institutions established in the place of Meeting, or in any place where the Association has formerly met.

5. Foreigners and other individuals whose assistance is desired, and who are specially nominated in writing for the Meeting of the year by the President and General Secretaries.

6. The Presidents, Vice-Presidents, and Secretaries of the Sections are *ex-officio* members of the General Committee for the time being.

### SECTIONAL COMMITTEES.

The General Committee shall appoint, at each Meeting, Committees, consisting severally of the Members most conversant with the several branches of Science, to advise together for the advancement thereof.

The Committees shall report what subjects of investigation they would particularly recommend to be prosecuted during the ensuing year, and brought under consideration at the next Meeting.

The Committees shall recommend Reports on the state and progress of particular Sciences, to be drawn up from time to time by competent persons, for the information of the Annual Meetings.

### COMMITTEE OF RECOMMENDATIONS.

The General Committee shall appoint at each Meeting a Committee, which shall receive and consider the Recommendations of the Sectional Committees, and report to the General Committee the measures which they would advise to be adopted for the advancement of Science.

All Recommendations of Grants of Money, Requests for Special Researches, and Reports on Scientific Subjects, shall be submitted to the Committee of Recommendations, and not taken into consideration by the General Committee, unless previously recommended by the Committee of Recommendations.

### LOCAL COMMITTEES.

Local Committees shall be formed by the Officers of the Association to assist in making arrangements for the Meetings.

Local Committees shall have the power of adding to their numbers those Members of the Association whose assistance they may desire.

### OFFICERS.

A President, two or more Vice-Presidents, one or more Secretaries, and a Treasurer, shall be annually appointed by the General Committee.

### COUNCIL.

In the intervals of the Meetings, the affairs of the Association shall be managed by a Council appointed by the General Committee. The Council may also assemble for the despatch of business during the week of the Meeting.

### PAPERS AND COMMUNICATIONS.

The Author of any paper or communication shall be at liberty to reserve his right of property therein.

### ACCOUNTS.

The Accounts of the Association shall be audited annually, by Auditors appointed by the Meeting.

# Table showing the Places and Times of Meeting of the British Association, with Presidents, Vice-Presidents, and Local Secretaries, from its Commencement.

| PRESIDENTS. | VICE-PRESIDENTS. | LOCAL SECRETARIES. |
|---|---|---|
| The EARL FITZWILLIAM, D.C.L., F.R.S., F.G.S., &c.<br>YORK, September 27, 1831. | Rev. W. Vernon Harcourt, M.A., F.R.S., F.G.S. | William Gray, jun., F.G.S.<br>Professor Phillips, M.A., F.R.S., F.G.S. |
| The REV. W. BUCKLAND, D.D., F.R.S., F.G.S., &c.<br>OXFORD, June 19, 1832. | Sir David Brewster, F.R.S. L. & E., &c.<br>Rev. W. Whewell, F.R.S., Pres. Geol. Soc. | Professor Daubeny, M.D., F.R.S., &c.<br>Rev. Professor Powell, M.A., F.R.S., &c. |
| The REV. ADAM SEDGWICK, M.A., V.P.R.S., V.P.G.S.<br>CAMBRIDGE, June 25, 1833. | G. B. Airy, F.R.S., Astronomer Royal, &c.<br>John Dalton, D.C.L., F.R.S. | Rev. Professor Henslow, M.A., F.L.S., F.G.S.<br>Rev. W. Whewell, F.R.S. |
| SIR T. MACDOUGALL BRISBANE, K.C.B., D.C.L., F.R.S. L. & E.<br>EDINBURGH, September 8, 1834. | Sir David Brewster, F.R.S., &c.<br>Rev. T. R. Robinson, D.D. | Professor Forbes, F.R.S. L. & E., &c.<br>Sir John Robinson, Sec. R.S.E. |
| The REV. PROVOST LLOYD, LL.D.<br>DUBLIN, August 10, 1835. | Viscount Oxmantown, F.R.S., F.R.A.S.<br>Rev. W. Whewell, F.R.S., &c. | Sir W. R. Hamilton, Astron. Royal of Ireland, &c.<br>Rev. Professor Lloyd, F.R.S. |
| The MARQUIS OF LANSDOWNE, D.C.L., F.R.S., &c.<br>BRISTOL, August 22, 1836. | The Marquis of Northampton, F.R.S.<br>Rev. W. D. Conybeare, F.R.S., F.G.S. J. C. Prichard, M.D., F.R.S. | Professor Daubeny, M.D., F.R.S., &c.<br>V. F. Hovenden, Esq. |
| The EARL OF BURLINGTON, F.R.S., F.G.S., Chancellor of the University of London<br>LIVERPOOL, September 11, 1837. | The Bishop of Norwich, P.L.S., F.G.S. John Dalton, D.C.L., F.R.S.<br>Sir Philip de Grey Egerton, Bart., F.R.S., F.G.S.<br>Rev. W. Whewell, F.R.S. | Professor Traill, M.D. Wm. Wallace Currie, Esq.<br>Joseph N. Walker, Pres. Royal Institution, Liverpool. |
| The DUKE OF NORTHUMBERLAND, F.R.S., F.G.S., &c.<br>NEWCASTLE-ON-TYNE, August 20, 1838. | The Bishop of Durham, F.R.S., F.S.A.<br>The Rev. W. Vernon Harcourt, F.R.S., &c.<br>Prideaux John Selby, Esq., F.R.S.E. | John Adamson, F.L.S., &c.<br>Wm. Hutton, F.G.S.<br>Professor Johnston, M.A., F.R.S. |
| The REV. W. VERNON HARCOURT, M.A., F.R.S., &c.<br>BIRMINGHAM, August 26, 1839. | Marquis of Northampton. Earl of Dartmouth.<br>The Rev. T. R. Robinson, D.D. John Corrie, Esq., F.R.S.<br>Very Rev. Principal Macfarlane | George Barker, Esq., F.R.S.<br>Peyton Blakiston, M.D.<br>Joseph Hodgson, Esq., F.R.S. Follett Os.er, Esq. |
| The MARQUIS OF BREADALBANE, F.R.S.<br>GLASGOW, September 17, 1840. | Major-General Lord Greenock, F.R.S.E. Sir David Brewster, F.R.S.<br>Sir T. M. Brisbane, Bart., F.R.S. The Earl of Mount Edgecumbe. | Andrew Liddell, Esq. Rev. J. P. Nicol, LL.D.<br>John Strang, Esq. |
| The REV. PROFESSOR WHEWELL, F.R.S., &c.<br>PLYMOUTH, July 29, 1841. | The Earl of Morley. Lord Eliot, M.P.<br>Sir C. Lemon, Bart.<br>Sir D. T. Acland, Bart. | W. Snow Harris, Esq., F.R.S.<br>Col. Hamilton Smith, F.L.S.<br>Robert Were Fox, Esq. Richard Taylor, jun., Esq. |
| The LORD FRANCIS EGERTON, F.G.S.<br>MANCHESTER, June 23, 1842. | John Dalton, D.C.L., F.R.S. Hon. and Rev. W. Herbert, F.L.S., &c.<br>Rev. A. Sedgwick, M.A., F.R.S. W. C. Henry, M.D., F.R.S.<br>Sir Benjamin Heywood, Bart. | Peter Clare, Esq., F.R.A.S.<br>W. Fleming, M.D.<br>James Heywood, Esq., F.R.S. |
| The EARL OF ROSSE, F.R.S.<br>CORK, August 17, 1843. | Earl of Listowel. Viscount Adare<br>Sir W. R. Hamilton, Pres.R.I.A.<br>Rev. T. R. Robinson, D.D. | Professor John Stevelly, M.A.<br>Rev. Jos. Carson, F.T.C. Dublin.<br>William Keleher, Esq. Wm. Clear, Esq. |

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| The REV. G. PEACOCK, D.D. (Dean of Ely), F.R.S.....<br>YORK, September 26, 1844. | Earl Fitzwilliam, F.R.S. Viscount Morpeth, F.G.S. .....<br>The Hon. John Stuart Wortley, M.P. Sir David Brewster, K.H., F.R.S.<br>Michael Faraday, Esq., D.C.L., F.R.S. .....<br>Rev. W. V. Harcourt, F.R.S..... | William Hatfeild, Esq., F.G.S.<br>Thomas Meynell, Esq., F.L.S.<br>Rev. W. Scoresby, LL.D., F.R.S.<br>William West, Esq. |
| SIR JOHN F. W. HERSCHEL, Bart., F.R.S., &c.....<br>CAMBRIDGE, June 19, 1845. | The Earl of Hardwicke. The Bishop of Norwich .....<br>Rev. J. Graham, D.D. Rev. G. Ainslie, D.D. .....<br>G. B. Airy, Esq., M.A., D.C.L., F.R.S. .....<br>The Rev. Professor Sedgwick, M.A., F.R.S. ..... | William Hopkins, Esq., M.A., F.R.S.<br>Professor Ansted, M.A., F.R.S. |
| SIR RODERICK IMPEY MURCHISON, G.C.St.S., F.R.S.<br>SOUTHAMPTON, September 10, 1846. | The Marquis of Winchester. The Earl of Yarborough, D.C.L.....<br>Lord Ashburton, D.C.L. Viscount Palmerston, M.P.....<br>Right Hon. Charles Shaw Lefevre, M.P.....<br>Sir George T. Staunton, Bart., M.P., D.C.L., F.R.S.....<br>The Lord Bishop of Oxford, F.R.S. .....<br>Professor Owen, M.D., F.R.S. Professor Powell, F.R.S. ..... | Henry Clark, M.D.<br>T. H. C. Moody, Esq. |
| SIR ROBERT HARRY INGLIS, Bart., D.C.L., F.R.S., M.P. for the University of Oxford .....<br>OXFORD, June 23, 1847. | The Earl of Rosse, F.R.S. The Lord Bishop of Oxford, F.R.S. .....<br>The Vice-Chancellor of the University .....<br>Thomas G. Bucknall Estcourt, Esq., D.C.L., M.P. for the University of Oxford. Very Rev. the Dean of Westminster, D.D., F.R.S.....<br>Professor Daubeny, M.D., F.R.S. The Rev. Prof. Powell, M.A., F.R.S. | Rev. Robert Walker, M.A., F.R.S.<br>H. Wentworth Acland, Esq., B.M. |
| The MARQUIS OF NORTHAMPTON, President of the Royal Society, &c. .....<br>SWANSEA, August 9, 1848. | The Marquis of Bute, K.T. Viscount Adare, F.R.S. .....<br>Sir H. T. DelaBeche, F.R.S., Pres. G.S. .....<br>The Very Rev. the Dean of Llandaff, F.R.S. .....<br>Lewis W. Dillwyn, Esq., F.R.S. W. R. Grove, Esq., F.R.S. .....<br>J. H. Vivian, Esq., M.P., F.R.S. The Lord Bishop of St. David's.... | Matthew Moggridge, Esq.<br>D. Nicol, M.D. |
| The REV. T. R. ROBINSON, D.D., M.R.I.A., F.R.A.S.<br>BIRMINGHAM, September 12, 1849. | The Earl of Harrowby. The Lord Wrottesley, F.R.S. .....<br>Right Hon. Sir Robert Peel, Bart., M.P., D.C.L., F.R.S. .....<br>Charles Darwin, Esq., M.A., F.R.S., Sec. G.S. .....<br>Professor Faraday, D.C.L., F.R.S. .....<br>Sir David Brewster, K.H., LL.D., F.R.S. Rev. Prof. Willis, M.A., F.R.S. | Captain Tindal, R.N.<br>William Wills, Esq.<br>Bell Fletcher, Esq., M.D.<br>James Chance, Esq. |
| SIR DAVID BREWSTER, K.H., LL.D., F.R.S. L. & E., Principal of the United College of St. Salvator and St. Leonard, St. Andrews. .....<br>EDINBURGH, July 21, 1850. | Right Hon. the Lord Provost of Edinburgh .....<br>The Earl of Cathcart, K.C.B., F.R.S.E. .....<br>The Earl of Rosebery, K.T., D.C.L., F.R.S. .....<br>Right Hon. David Boyle (Lord Justice-General), F.R.S.E. .....<br>General Sir Thomas M. Brisbane, Bart., D.C.L., F.R.S., Pres. R.S.E...<br>Very Rev. John Lee, D.D., V.P.R.S.E., Principal of the University of Edinburgh. Professor W. P. Alison, M.D., V.P.R.S.E. .....<br>Professor J. D. Forbes, F.R.S., Sec. R.S.E. ..... | Rev. Professor Kelland, M.A., F.R.S.L. & E.<br>Professor Balfour, M.D., F.R.S.E., F.L.S.<br>James Tod, Esq., F.R.S.E. |

| PRESIDENTS. | VICE-PRESIDENTS. | LOCAL SECRETARIES. |
|---|---|---|
| [illegible] Esq., D.C.L., F.R.S., Astronomer Royal. [illegible] | The Lord Rendlesham, M.P. — The Lord Bishop of Norwich<br>Rev. Professor Sedgwick, M.A., F.R.S.<br>Rev. Professor Henslow, M.A., F.L.S.<br>Sir John P. Boileau, Bart., F.R.S. — Sir William F. F. Middleton, Bart.<br>J. C. Cobbold, Esq., M.P. — T. B. Western, Esq. | Charles May, Esq., F.R.A.S.<br>Dillwyn Sims, Esq.<br>George Arthur Biddell, Esq.<br>George Ransome, Esq., F.L.S. |
| MAJOR-GENERAL EDWARD SABINE, Royal Artillery, Treas. & V.P. of the Royal Society<br>BELFAST, September 1, 1852. | The Earl of Enniskillen, D.C.L., F.R.S.<br>The Earl of Rosse, M.R.I.A., Pres. R.S.<br>Sir Henry T. DelaBeche, F.R.S.<br>Rev. Edward Hincks, D.D., M.R.I.A.<br>Rev. F. S. Henry, D.D., Pres. Queen's College, Belfast<br>Rev. T. R. Robinson, D.D., Pres. R.I.A., F.R.A.S.<br>Professor G. G. Stokes, F.R.S. — Professor Stevelly, LL.D. | W. J. C. Allen, Esq.<br>William M'Gee, M.D.<br>Professor W. P. Wilson. |
| WILLIAM HOPKINS, Esq., M.A., V.P.R.S., F.G.S., & Pres. Camb. Phil. Society<br>HULL, September 7, 1853. | The Earl of Carlisle, F.R.S. — Lord Londesborough, F.R.S.<br>Professor Faraday, D.C.L., F.R.S. — Rev. Prof. Sedgwick, M.A., F.R.S.<br>Charles Frost, Esq., F.S.A., Pres. of the Hull Lit. and Philos. Society<br>William Spence, Esq., F.R.S. — Lieut.-Col. Sykes, F.R.S.<br>Professor Wheatstone, F.R.S. | Henry Cooper, M.D., V.P. Hull. Lit. & Phil. Society.<br>Bethel Jacobs, Esq., Pres. Hull Mechanics' Inst. |
| The EARL OF HARROWBY, F.R.S.<br>LIVERPOOL, September 20, 1854. | The Lord Wrottesley, M.A., F.R.S., F.R.A.S.<br>Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S.<br>Professor Owen, M.D., LL.D., F.R.S., F.L.S., F.G.S.<br>Rev. Professor Whewell, D.D., F.R.S., Hon. M.R.I.A., F.G.S., Master of Trinity College, Cambridge<br>William Lassell, Esq., F.R.S.L. & E., F.R.A.S.<br>Joseph Brooks Yates, F.S.A., F.R.G.S. | Joseph Dickinson, M.D., F.R.S.<br>Thomas Inman, M.D. |
| The DUKE OF ARGYLL, F.R.S., F.G.S.<br>GLASGOW, September 12, 1855. | The Very Rev. Principal Macfarlane, D.D.<br>Sir William Jardine, Bart., F.R.S.E.<br>Sir Charles Lyell, M.A., LL.D., F.R.S.<br>James Smith, Esq., F.R.S. L. & E.<br>Walter Crum, Esq., F.R.S.<br>Thomas Graham, Esq., M.A., F.R.S., Master of the Royal Mint<br>Professor William Thomson, M.A., F.R.S. | John Strang, LL.D.<br>Professor Thomas Anderson, M.D.<br>William Gourlie, Esq. |
| CHARLES G. B. DAUBENY, M.D., LL.D., F.R.S., Professor of Botany in the University of Oxford<br>CHELTENHAM, August 6, 1856. | The Earl of Ducie, F.R.S., F.G.S.<br>The Lord Bishop of Gloucester and Bristol<br>Sir Roderick I. Murchison, G.C.St.S., D.C.L., F.R.S.<br>Thomas Barwick Lloyd Baker, Esq. — The Rev. Francis Close, M.A. | Capt. Robinson, R.A.<br>Richard Beamish, Esq., F.R.S.<br>John West Hugall, Esq. |
| The REV. HUMPHREY LLOYD, D.D., D.C.L., F.R.S. L. & E., V.P.R.I.A.<br>DUBLIN, August 26, 1857. | The Right Honourable the Lord Mayor of Dublin<br>The Provost of Trinity College, Dublin<br>The Marquis of Kildare. — Lord Talbot de Malahide<br>The Lord Chancellor of Ireland<br>The Lord Chief Baron, Dublin<br>Sir William R. Hamilton, LL.D., F.R.A.S., Astronomer Royal of Ireland<br>Lieut.-Colonel Larcom, R.E., LL.D., F.R.S.<br>Richard Griffith, Esq., LL.D., M.R.I.A., F.R.S.E., F.G.S. | Lundy E. Foote, Esq.<br>Rev. Professor Jellett, F.T.C.D.<br>W. Neilson Hancock, LL.D. |

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| **RICHARD OWEN, M.D., D.C.L., V.P.R.S., F.L.S., F.G.S.,** **Superintendent of the Natural History Departments of the British Museum** ..... **LEEDS, September 22, 1858.** | The Lord Monteagle, F.R.S. .....<br>The Lord Viscount Goderich, M.P., F.R.G.S. .....<br>The Right Hon. M. T. Baines, M.A., M.P. .....<br>Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S. .....<br>The Rev. W. Whewell, D.D., F.R.S., Hon. M.R.I.A., F.G.S., F.R.A.S., Master of Trinity College, Cambridge .....<br>James Garth Marshall, Esq., M.A., F.G.S. .....<br>R. Monckton Milnes, Esq., D.C.L., M.P., F.R.G.S. ..... | **Rev. Thomas Hincks, B.A.**<br>**W. Sykes Ward, Esq., F.C.S.**<br>**Thomas Wilson, Esq., M.A.** |
| **HIS ROYAL HIGHNESS THE PRINCE CONSORT ..** **ABERDEEN, September 14, 1859.** | **The Duke** of Richmond, K.G., F.R.S. .....<br>**The Earl** of Aberdeen, LL.D., K.G., K.T., F.R.S. .....<br>**The Lord** Provost of the City of Aberdeen. .....<br>**Sir John F.** W. Herschel, Bart., M.A., D.C.L., **F.R.S.** .....<br>**Sir David** Brewster, K.H., D.C.L., F.R.S. .....<br>**Sir Roderick** I. Murchison, G.C.St.S., D.C.L., **F.R.S.** .....<br>**The Rev.** W. V. Harcourt, M.A., F.R.S. .....<br>**The Rev.** T. R. Robinson, D.D., F.R.S. .....<br>**A. Thomson**, Esq., LL.D., F.R.S., Convener of the County of Aberdeen.. | **Professor J. Nicol, F.R.S.E., F.G.S.**<br>**Professor Fuller, M.A.**<br>**John F. White, Esq.** |
| **The LORD WROTTESLEY, M.A., V.P.R.S., F.R.A.S. ..** **OXFORD, June 27, 1860.** | The Earl of Derby, K.G., P.C., D.C.L., Chancellor of the Univ. of Oxford ..<br>The Rev. F. Jeune, D.C.L., Vice-Chancellor of the University of Oxford ..<br>The Duke of Marlborough, D.C.L., F.G.S., Lord Lieutenant of Oxfordshire<br>The Earl of Rosse, K.P., M.A., F.R.S., F.R.A.S. .....<br>The Lord Bishop of Oxford, D.D., F.R.S. .....<br>The Very Rev. H. G. Liddell, D.D., Dean of Christ Church, Oxford .....<br>Professor Daubeny, M.D., LL.D., F.R.S., F.L.S., F.G.S. .....<br>Professor Acland, M.D., F.R.S. Professor Donkin, M.A., F.R.S., F.R.A.S. | **George Rolleston, M.D., F.L.S.**<br>**H. J. S. Smith, Esq., M.A., F.C.S.**<br>**George Griffith, Esq., M.A., F.C.S.** |
| **WILLIAM FAIRBAIRN, Esq., LL.D., C.E., F.R.S. ....** **MANCHESTER, September 4, 1861.** | The Earl of Ellesmere, F.R.G.S. .....<br>The Lord Stanley, M.P., D.C.L., F.R.G.S. .....<br>The Lord Bishop of Manchester, D.D., F.R.S., F.G.S. .....<br>Sir Philip de M. Grey Egerton, Bart., M.P., F.R.S., F.G.S. .....<br>Sir Benjamin Heywood, Bart., F.R.S. .....<br>Thomas Bazley, Esq., M.P. .....<br>James Aspinall Turner, Esq., M.P. .....<br>James Prescott Joule, Esq., LL.D., F.R.S., Pres. Lit. & Phil. Soc. Manchester. .....<br>Professor E. Hodgkinson, F.R.S., M.R.I.A., M.I.C.E. .....<br>Joseph Whitworth, Esq., F.R.S., M.I.C.E. ..... | **R. D. Darbishire, Esq., B.A., F.G.S.**<br>**Alfred Neild, Esq.**<br>**Arthur Ransome, M.A., Esq.**<br>**Professor H. E. Roscoe, B.A.** |
| **The REV. R. WILLIS, M.A., F.R.S., Jacksonian Professor of Natural and Experimental Philosophy in the University of Cambridge** ..... **CAMBRIDGE, October 1, 1862.** | The Rev. the Vice-Chancellor of the University of Cambridge .....<br>The Very Rev. Harvey Goodwin, D.D., Dean of Ely. .....<br>The Rev. W. Whewell, D.D., F.R.S., Master of Trinity College, Cambridge<br>The Rev. Professor Sedgwick, M.A., D.C.L., F.R.S. .....<br>Rev. J. Challis, M.A., F.R.S. .....<br>G. B. Airy, Esq., M.A., D.C.L., F.R.S., Astronomer Royal .....<br>Professor G. G. Stokes, M.A., D.C.L., Sec. R.S. .....<br>Professor J. C. Adams, M.A., D.C.L., F.R.S., Pres. C.P.S. ..... | **Professor C. C. Babington, M.A., F.R.S., F.L.S.**<br>**Professor G. D. Liveing, M.A.**<br>**The Rev. N. M. Ferrers, M.A.** |

| PRESIDENTS. | VICE-PRESIDENTS. | LOCAL SECRETARIES. |
|---|---|---|
| SIR W. ARMSTRONG, C.B., LL.D., F.R.S.<br>NEWCASTLE-ON-TYNE, August 26, 1863. | Sir Walter C. Trevelyan, Bart., M.A.<br>Sir Charles Lyell, LL.D., D.C.L., F.R.S., F.G.S.<br>Hugh Taylor, Esq., Chairman of the Coal Trade<br>Isaac Lowthian Bell, Esq., Mayor of Newcastle.<br>Nicholas Wood, Esq., President of the Northern Institute of Mining Engineers<br>Rev. Temple Chevallier, B.D., F.R.A.S.<br>William Fairbairn, Esq., LL.D., F.R.S. | A. Noble, Esq.<br>Augustus H. Hunt, Esq.<br>R. C. Clapham, Esq. |
| SIR CHARLES LYELL, Bart., M.A., D.C.L,, F.R.S.<br>BATH, September 14, 1864. | The Right Hon. the Earl of Cork and Orrery, Lord Lieutenant of Somersetshire<br>The Most Noble the Marquis of Bath<br>The Right Hon. Earl Nelson<br>The Right Hon. Lord Portman<br>The Very Reverend the Dean of Hereford<br>The Venerable the Archdeacon of Bath<br>W. Tite, Esq., M.P., F.R.S., F.G.S., F.S.A.<br>A. E. Way, Esq., M.P.<br>Francis H. Dickinson, Esq.<br>W. Sanders, Esq. F.R.S., F.G.S. | C. Moore, Esq., F.G.S.<br>C. E. Davis, Esq.<br>The Rev. H. H. Winwood, M.A. |
| JOHN PHILLIPS, Esq., M.A., LL.D., F.R.S., F.G.S., Professor of Geology in the University of Oxford<br>BIRMINGHAM, September 6, 1865. | The Right Hon. the Earl of Lichfield, Lord-Lieutenant of Staffordshire.<br>The Right Hon. the Earl of Dudley<br>The Right Hon. Lord Leigh, Lord-Lieutenant of Warwickshire<br>The Right Hon. Lord Lyttelton, Lord-Lieutenant of Worcestershire<br>The Right Hon. Lord Wrottesley, M.A., D.C.L., F.R.S., F.R.A.S.<br>The Right Reverend the Lord Bishop of Worcester<br>The Right Hon. C. B. Adderley, M.P.<br>William Scholefield, Esq., M.P. — F. Osler, Esq., F.R.S.<br>J. T. Chance, Esq. — The Rev. Charles Evans, M.A. | William Mathews, Esq., jun., F.G.S.<br>John Henry Chamberlain, Esq.<br>The Rev. G. D. Boyle, M.A. |
| WILLIAM R. GROVE, Esq., Q.C., M.A., F.R.S.<br>NOTTINGHAM, August 22, 1866. | His Grace the Duke of Devonshire, Lord-Lieutenant of Derbyshire<br>His Grace the Duke of Rutland, Lord-Lieutenant of Leicestershire<br>The Right Hon. Lord Belper, Lord-Lieutenant of Nottinghamshire.<br>The Right Hon. J. E. Denison, M.P.<br>J. C. Webb, Esq., High-Sheriff of Nottinghamshire<br>Thomas Graham, Esq., F.R.S., Master of the Mint.<br>Joseph Hooker, M.D., F.R.S., F.L.S.<br>John Russell Hinds, Esq., F.R.S., F.R.A.S.<br>T. Close, Esq. | Dr. Robertson.<br>Edward J. Lowe, Esq., F.R.A.S., F.L.S.<br>The Rev. J. F. M'Callan, M.A. |
| HIS GRACE THE DUKE OF BUCCLEUCH, K.G., D.C.L., F.R.S.<br>DUNDEE, September 4, 1867. | The Right Hon. The Earl of Airlie, K.T.<br>The Right Hon. The Lord Kinnaird, K.T.<br>Sir John Ogilvy, Bart., M.P.<br>Sir Roderick I. Murchison, Bart., K.C.B., LL.D., F.R.S., F.G.S., &c.<br>Sir David Baxter, Bart.<br>Sir David Brewster, D.C.L., F.R.S., Principal of the University of Edinburgh.<br>James D. Forbes, LL.D., F.R.S., Principal of the United College St. Salvator and St. Leonards, University of St. Andrews | J. Henderson, Esq.<br>John Austin Lake Gloag, Esq.<br>Patrick Anderson, Esq. |

## THE GENERAL TREASURER'S ACCOUNT from September 6, 1865 (commencement of BIRMINGHAM MEETING) to August 22, 1866 (NOTTINGHAM).

### RECEIPTS.

| | £ | s. | d. |
|---|---|---|---|
| To Balance brought from last Account | 759 | 2 | 6 |
| Received for Life Compositions at Birmingham Meeting and since | 440 | 0 | 0 |
| „ Annual Subscriptions, ditto ditto | 671 | 0 | 0 |
| „ Associates' Tickets, ditto ditto | 768 | 0 | 0 |
| „ Ladies' Tickets, ditto ditto | 508 | 0 | 0 |
| „ Dividends on Stock, 1 year | 250 | 15 | 0 |
| „ Sale of Publications—viz. | | | |
| Reports ..... 45 2 8 | | | |
| Index, Catalogue of Stars, &c. ..... 53 12 10 | | | |
| | 98 | 15 | 6 |
| | £3495 | 13 | 0 |

### PAYMENTS.

| | £ | s. | d. |
|---|---|---|---|
| By paid Expenses of Birmingham Meeting, Sundry Printing, Binding, Advertising, and Incidental Petty Expenses | 259 | 5 | 9 |
| Paid for Printing, Engraving, and Binding Report of 34th Meeting (Bath) | 632 | 3 | 9 |
| For Salaries (12 months) | 350 | 0 | 0 |
| Paid on account of Grants made at Birmingham Meeting, viz.— | | | |
| For Maintaining Establishment of Kew Observatory ... £600 0 0 | | | |
| Lunar Committee ... 64 13 4 | | | |
| Balloon Committee ... 50 0 0 | | | |
| Metrical Committee ... 50 0 0 | | | |
| Committee on British Rainfall ... 50 0 0 | | | |
| „ Kilkenny Coal Fields ... 16 0 0 | | | |
| „ Alum Bay Fossil Leaf Bed ... 15 0 0 | | | |
| „ Luminous Meteors ... 50 0 0 | | | |
| „ Lingula Flags Excavation ... 20 0 0 | | | |
| „ Chemical Constitution of Cast Iron ... 50 0 0 | | | |
| „ Amyl Compounds ... 25 0 0 | | | |
| „ Electrical Standards ... 100 0 0 | | | |
| „ Malta Caves Exploration ... 30 0 0 | | | |
| „ Kent's Hole Exploration ... 200 0 0 | | | |
| „ Marine Fauna, &c., Devon and Cornwall ... 25 0 0 | | | |
| „ Dredging Aberdeenshire Coast ... 25 0 0 | | | |
| „ Do. Hebrides Coast ... 50 0 0 | | | |
| „ Do. the Mersey ... 5 0 0 | | | |
| „ Resistance of Floating Bodies in Water ... 50 0 0 | | | |
| „ Polycyanides of Organic Radicals ... 20 0 0 | | | |
| „ Rigor Mortis ... 10 0 0 | | | |
| „ Irish Annelida ... 15 0 0 | | | |
| „ Catalogue of Crania ... 50 0 0 | | | |
| „ Didine Birds of Mascarene Islands ... 50 0 0 | | | |
| „ Typical Crania Researches ... 30 0 0 | | | |
| „ Palestine Exploration Fund ... 100 0 0 | | | |
| | 1750 | 13 | 4 |
| Balance at London and Westminster Bank ... £500 12 11 | | | |
| „ in hands of General Treasurer ... 2 17 3 | | | |
| | 503 | 10 | 2 |
| | £3495 | 13 | 0 |

## II. Table showing the Names of Members of the British Association who have served on the Council in former years.

Aberdeen, Earl of, LL.D., K.G., K.T., F.R.S. (deceased).
Acland, Sir T. D., Bart., M.A., D.C.L., F.R.S.
Acland, Professor H. W., M.D., F.R.S.
Adams, Prof. J. Couch, M.A., D.C.L., F.R.S.
Adamson, John, Esq., F.L.S.
Adderley, The Right Hon. C.B., M.P.
Ainslie, Rev. Gilbert, D.D., Master of Pembroke Hall, Cambridge.
Airy, G. B., M.A., D.C.L., F.R.S., Astr. Royal.
Alison, Professor W. P., M.D., F.R.S.E. (dec$^{d}$).
Allen, W. J. C., Esq.
Anderson, Prof. Thomas, M.D.
Ansted, Professor D. T., M.A., F.R.S.
Argyll, G. Douglas, Duke of, F.R.S. L. & E.
Armstrong, Sir W. G., F.R.S.
Arnott, Neil, M.D., F.R.S.
Ashburton, William Bingham, Lord, D.C.L. (deceased).
Atkinson, Rt. Hon. R., late Lord Mayor of Dublin.
Babbage, Charles, Esq., M.A., F.R.S.
Babington, Professor C. C., M.A., F.R.S.
Baily, Francis, Esq., F.R.S. (deceased).
Baines, Rt. Hon. M. T., M.A., M.P. (dec$^{d}$).
Baker, Thomas Barwick Lloyd, Esq.
Balfour, Professor John H., M.D., F.R.S.
Barker, George, Esq., F.R.S. (deceased).
Bath, The Most Noble the Marquis of.
Bath, The Venerable the Archdeacon of.
Beamish, Richard, Esq., F.R.S.
Beechey, Rear-Admiral, F.R.S. (deceased).
Bell, Isaac Lowthian, Esq.
Bell, Professor Thomas, V.P.L.S., F.R.S.
Belper, Lord, D.C.L., F.R.S., F.G.S.
Bengough, George, Esq.
Bentham, George, Esq., Pres.L.S.
Biddell, George Arthur, Esq.
Bigge, Charles, Esq.
Blakiston, Peyton, M.D., F.R.S.
Boileau, Sir John P., Bart., F.R.S.
Boyle, Right Hon. D., Lord Justice-General (deceased).
Boyle, Rev. G. D., M.A.
Brady, The Rt. Hon. Maziere, M.R.I.A., Lord Chancellor of Ireland.
Brand, William, Esq.
Breadalbane, John, Marquis of, K.T., F.R.S. (deceased).
Brewster, Sir David, K.H., D.C.L., LL.D., F.R.S. L. & E., Principal of the University of Edinburgh.
Brisbane, General Sir Thomas M., Bart., K.C.B., G.C.H., D.C.L., F.R.S. (dec$^{d}$).
Brodie, Sir B. C., Bart., D.C.L., P.R.S. (deceased).
Brooke, Charles, B.A., F.R.S.
Brown, Robert, D.C.L., F.R.S. (deceased).
Brunel, Sir M. I., F.R.S. (deceased).
Buckland, Very Rev. William, D.D., F.R.S., Dean of Westminster (deceased).
Bute, John, Marquis of, K.T. (deceased).
Carlisle, G. W. Fred., Earl of, F.R.S. (dec$^{d}$).
Carson, Rev. Joseph, F.T.C.D.
Cathcart, Lt.-Gen., Earl of, K.C.B., F.R.S.E. (deceased).
Challis, Rev. J., M.A., F.R.S.
Chalmers, Rev. T., D.D. (deceased).
Chamberlain, John Henry, Esq.
Chance, James, Esq.
Chance, J. T., Esq.
Chester, John Graham, D.D., Lord Bishop of (deceased).
Chevallier, Rev. Temple, B.D., F.R.A.S.
Christie, Professor S. H., M.A., F.R.S. (dec$^{d}$).
Clapham, R. C., Esq.
Clare, Peter, Esq., F.R.A.S. (deceased).
Clark, Rev. Prof., M.D., F.R.S. (Cambridge.)
Clark, Henry, M.D.
Clark, G. T., Esq.
Clear, William, Esq. (deceased).
Clerke, Major S., K.H., R.E., F.R.S. (dec$^{d}$).
Clift, William, Esq., F.R.S. (deceased).
Close, Very Rev. F., M.A., Dean of Carlisle.
Close, Thomas, Esq.
Cobbold, John Chevalier, Esq., M.P.
Colquhoun, J. C., Esq., M.P. (deceased).
Conybeare, Very Rev. W. D., Dean of Llandaff (deceased).
Cooper, Sir Henry, M.D.
Cork and Orrery, The Rt. Hon. the Earl of, Lord-Lieutenant of Somersetshire.
Corrie, John, Esq., F.R.S. (deceased).
Crum, Walter, Esq., F.R.S.
Currie, William Wallace, Esq. (deceased).
Dalton, John, D.C.L., F.R.S. (deceased).
Daniell, Professor J. F., F.R.S. (deceased).
Darbishire, R. D., Esq., B.A., F.G.S.
Dartmouth, William, Earl of, D.C.L., F.R.S.
Darwin, Charles, Esq., M.A., F.R.S.
Daubeny, Prof. C. G. B., M.D., LL.D., F.R.S.
Davis, C. E., Esq., F.S.A.
DelaBeche, Sir H. T., C.B., F.R.S., Director-Gen. Geol. Surv. United Kingdom (dec$^{d}$).
De la Rue, Warren, Ph.D., F.R.S.
Denison, The Rt. Hon. M.P.
Derby, Earl of, D.C.L., Chancellor of the University of Oxford.
Devonshire, W., Duke of, M.A., D.C.L., F.R.S.
Dickinson, Francis H., Esq.
Dickinson, Joseph, M.D., F.R.S.
Dillwyn, Lewis W., Esq., F.R.S. (deceased).

Donkin, Professor W. F., M.A., F.R.S.
Drinkwater, J. E., Esq. (deceased).
Ducie, The Earl of, F.R.S.
Dudley, The Right Hon. the Earl of.
Dunraven, The Earl of, F.R.S.
Egerton, Sir P. de M. Grey, Bart., M.P., F.R.S.
Eliot, Lord, M.P.
Ellesmere, Francis, Earl of, F.G.S. (dec$^{d}$).
Enniskillen, William, Earl of, D.C.L., F.R.S.
Estcourt, T. G. B., D.C.L. (deceased).
Evans, The Rev. Charles, M.A.
Fairbairn, William, LL.D., C.E., F.R.S.
Faraday, Professor, D.C.L., F.R.S.
Ferrers, Rev. N. M., M.A.
FitzRoy, Rear-Admiral, F.R.S. (deceased).
Fitzwilliam, The Earl, D.C.L., F.R.S. (dec$^{d}$).
Fleming, W., M.D.
Fletcher, Bell, M.D.
Foote, Lundy E., Esq.
Forbes, Charles, Esq. (deceased).
Forbes, Prof. Edward, F.R.S. (deceased).
Forbes, Prof. J. D., LL.D., F.R.S., Sec. R.S.E., Principal of University of St. Andrews.
Fox, Robert Were, Esq., F.R.S.
Frost, Charles, F.S.A.
Fuller, Professor, M.A.
Galton, Francis, F.R.S., F.G.S.
Gassiot, John P., Esq., F.R.S.
Gilbert, Davies, D.C.L., F.R.S. (deceased).
Gladstone, J. H., Ph.D., F.R.S.
Goodwin, The Very Rev. H., D.D., Dean of Ely.
Gourlie, William, Esq. (deceased).
Graham, T., M.A., D.C.L., F.R.S., Master of the Mint.
Gray, John E., Esq., Ph.D., F.R.S.
Gray, Jonathan, Esq. (deceased).
Gray, William, Esq., F.G.S.
Green, Prof. Joseph Henry, D.C.L., F.R.S. (deceased).
Greenough, G. B., Esq., F.R.S. (deceased).
Griffith, George, M.A., F.C.S.
Griffith, Sir R. Griffith, Bt., LL.D., M.R.I.A.
Grove, W. R., Esq., M.A., F.R.S.
Hallam, Henry, Esq., M.A., F.R.S. (dec$^{d}$).
Hamilton, W. J., Esq., F.R.S., F.G.S. (dec$^{d}$)
Hamilton, Sir Wm. R., LL.D., Astronomer Royal of Ireland, M.R.I.A., F.R.A.S. (deceased).
Hancock, W. Neilson, LL.D.
Harcourt, Rev. Wm. Vernon, M.A., F.R.S.
Hardwicke, Charles Philip, Earl of, F.R.S.
Harford, J. S., D.C.L., F.R.S. (deceased).
Harris, Sir W. Snow, F.R.S. (deceased).
Harrowby, The Earl of, F.R.S.
Hatfeild, William, Esq., F.G.S. (deceased).
Henry, W. C., M.D., F.R.S.
Henry, Rev. P. S., D.D., President of Queen's College, Belfast.
Henslow, Rev. Professor, M.A., F.L.S. (dec$^{d}$).
Herbert, Hon. and Very Rev. Wm., LL.D., F.L.S., Dean of Manchester (dec$^{d}$).
Hereford, The Very Rev. the Dean of (dec$^{d}$).
Herschel, Sir John F. W., Bart., M.A., D.C.L., F.R.S.
Heywood, Sir Benjamin, Bart., F.R.S. (deceased).
Heywood, James, Esq., F.R.S.
Hill, Rev. Edward, M.A., F.G.S.
Hincks, Rev. Edward, D.D., M.R.I.A. (dec$^{d}$).
Hincks, Rev. Thomas, B.A.
Hinds, John Russell, Esq., F.R.S.
Hinds, S., D.D., late Lord Bishop of Norwich (deceased).
Hodgkin, Thomas, M.D.
Hodgkinson, Professor Eaton, F.R.S. (dec$^{d}$).
Hodgson, Joseph, Esq., F.R.S.
Hogg, John, Esq., M.A., F.L.S.
Hooker, Joseph, M.D., F.R.S.
Hooker, Sir William J., LL.D., F.R.S. (deceased).
Hope, Rev. F. W., M.A., F.R.S. (deceased).
Hopkins, William, Esq., M.A., LL.D., F.R.S. (deceased).
Horner, Leonard, Esq., F.R.S. (deceased).
Houghton, Lord, D.C.L.
Hovenden, V. F., Esq., M.A.
Hugall, J. W., Esq.
Hunt, Aug. H., Esq., B.A., Ph.D.
Hutton, Robert, Esq., F.G.S.
Hutton, William, Esq., F.G.S. (deceased).
Ibbetson, Capt. L. L. Boscawen, K.R.E., F.G.S.
Inglis, Sir R. H., Bart., D.C.L., M.P. (deceased).
Inman, Thomas, M.D.
Jacobs, Bethel, Esq.
Jameson, Professor R., F.R.S. (deceased).
Jardine, Sir William, Bart., F.R.S.E.
Jeffreys, John Gwyn, Esq., F.R.S.
Jellett, Rev. Professor.
Jenyns, Rev. Leonard, F.L.S.
Jerrard, H. B., Esq.
Jeune, The Right Rev. F., D.C.L.
Johnston, Right Hon. William, late Lord Provost of Edinburgh.
Johnston, Prof. J. F. W., M.A., F.R.S. (dec$^{d}$).
Keleher, William, Esq. (deceased).
Kelland, Rev. Prof. P., M.A., F.R.S. L. & E.
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Dr. Otto Torell, *University of Lund.*
Dr. Van der Hoeven, *Leyden.*
M. Vámbéry, *Hungary.*
M. de Verneuil, *Paris.*
Baron Sartorius von Waltershausen, *Göttingen.*
Professor Wartmann, *Geneva.*
Dr. Welwitsch.

## *Report of the Council of the British Association, presented to the General Committee, Wednesday, August 22,* 1866.

The Council have the honour to report as follows:—

The Council have received a Report from the Treasurer at each of their Meetings, and a Report for the year will be presented to the General Committee this day.

The Report of the Parliamentary Committee has been received for presentation to the General Committee.

The Kew Committee have presented to the Council a Report for the year 1865–66, which will be laid before the General Committee this day.

The Council have added to the list of Corresponding Members the names of the following Foreign Men of Science who attended the Birmingham Meeting, viz.:—

| | |
|---|---|
| Capt. Belavenetz. | Prof. Kiepert. |
| Geheimrath von Dechen. | Prof. F. Römer. |
| M. Gaudry. | Chev. C. Negri. |
| Prof. Grube. | Prof. Steenstrup. |

The Council recommend that the names of Mr. J. Hind, F.R.S., and Mr. T. Close, be added to the list of Vice-Presidents of the Meeting.

In consequence of the resignation of Mr. Hopkins as Joint General Secretary, announced last year, the Council appointed a Committee, consisting of the General Secretaries and the Gentlemen who had formerly filled that office, for the purpose of taking into consideration and reporting to the Council on the advisability of nominating a Joint General Secretary. The Council have received the following Report, viz.:—

> "That Thomas Archer Hirst, Esq., Ph.D., F.R.S., Professor of Mathethematical Physics in University College, London, be recommended as highly qualified for Election as Joint General Secretary of the Association."

The Council recommend that Mr. Hirst, F.R.S., be elected Joint General Secretary.

The Council have been informed that invitations for future Meetings of the Association have been received from Dundee, Norwich, Plymouth, and Exeter.

## *Report of the Kew Committee of the British Association for the Advancement of Science for* 1865–66.

The Committee of the Kew Observatory submit to the Council of the British Association the following statement of their proceedings during the past year:—

A Unifilar and Dip Circle for Captain J. Belavenetz, of the Russian Navy, Director of the Compass Observatory at Cronstadt, have been verified at Kew Observatory and forwarded to Russia.

Three Unifilars and three Dip Circles, ordered by Colonel Strange for the Indian Survey, have been verified.

Dr. Kirk, who has gone out to Zanzibar on the African coast, has received instruction at Kew Observatory; and a Dip Circle, a Unifilar, and an Azimuth Compass have been verified for him, and await his directions.

In consequence of a representation from Mr. C. Chambers, Acting Superintendent of the Observatory, Bombay, a correspondence has taken place between the Director of the India Store Department and the Chairman of

the Kew Committee, the result of which is that the Committee have superintended the construction of an Anemometer, a Dip Circle, and a Unifilar for the Bombay Observatory. These instruments have been verified, and are now in the hands of the India Board for transmission to their destination.

The Admiralty have ordered a Unifilar and a Dip Circle for Captain Mayne, of Her Majesty's ship 'Nassau,' who is about to proceed to the Straits of Magellan; these instruments have been verified at Kew Observatory, where Captain Mayne and several of his officers have likewise received instruction in magnetism.

Dr. Buys-Ballot has ordered a Declination Magnetograph, which has been constructed by Mr. Adie, and forwarded to Utrecht, where it has safely arrived.

A set of Self-recording Magnetographs and also a Barograph have been ordered by the Stonyhurst Observatory; and the Rev. Walter Sidgreaves has been at the Observatory receiving instruction in magnetism. The Self-recording Magnetographs for Stonyhurst have been verified and dispatched to their destination.

The set of self-recording instruments ordered by Mr. Meldrum of the Mauritius Observatory, are at present at Kew; Mr. Meldrum intends to visit the Kew Observatory for the purpose of making himself further acquainted with the process of observing and deducing results previous to his return to the Mauritius.

Mr. Ellery, of Melbourne Observatory, has likewise ordered a set of Self-recording magnetographs. These have been constructed by Mr. Adie, and will be taken to Kew for verification when the set for Mauritius have been removed.

Professor Smirnow (from Kasan) has received instruction in magnetism at the Observatory.

The usual monthly absolute determinations of the magnetic elements continue to be made by Mr. Whipple, Magnetical Assistant, and the self-recording magnetographs are in constant operation as heretofore, also under Mr. Whipple, who has displayed his usual care and assiduity in the discharge of his duties.

The photographic department connected with the self-recording instruments is under the charge of Mr. Page, who performs his duties very satisfactorily.

A stoneware stove free from iron has been erected in the room containing the Kew magnetographs, and by its means this room has been heated through a range of 20° Fahr., in order to determine the temperature correction of the horizontal and vertical force magnetographs. The observations for this purpose are being reduced.

The meteorological work of the Observatory continues in charge of Mr. Baker, who executes his duties very satisfactorily.

Since the Birmingham Meeting 126 barometers have been verified: 395 thermometers have likewise been verified, and 8 standard thermometers constructed at the Observatory.

The Self-recording Barograph continues in constant operation; and traces in duplicate are obtained, one set of which is regularly forwarded to the meteorological department of the Board of Trade.

An arrangement for a Self-recording Thermograph has been devised by the Superintendent and by Mr. Beckley, and, as a preliminary experiment, gave a very satisfactory curve; the instrument is now being arranged in a suitable site.

The instruments used by the late Mr. Appold for regulating the tempera-

ture and moisture of his apartments have been forwarded by the Royal Society to the Kew Observatory.

The Indian pendulum observations are in active progress. Both Colonel Walker and Captain Basevi are in correspondence with the Observatory in discussing questions relating to this work.

The Superintendent has received £100 from the Government Grant Committee of the Royal Society for preliminary observation with Captain Kater's pendulum. These preliminary observations are in progress under the charge of Mr. Loewy as observer, and have the following points in view:—

(1) To see by the general agreement or non-agreement of the observations with each other whether Captain Kater's pendulum is still in a state to justify its adoption as an instrument to give a correct determination of the length of the seconds' pendulum.

(2) To determine the true temperature correction of the pendulum.

(3) To use Kater's pendulum, and also the Royal Society's invariable pendulum No. 8, for the purpose of determining a curve of correction for atmospheric pressure, from inch to inch, at low pressures.

The Superintendent has received £50 from the Government Grant Fund of the Royal Society, to pursue the experiments on a rotating disk.

The Kew Heliograph, in charge of Mr. De la Rue, continues to be worked in a very satisfactory manner. During the past year 282 negatives have been taken on 158 days, and the usual number of positives have been printed from them.

Since the last Meeting of the Association, the first set of the results obtained by this instrument have been published at the expense of Mr. De la Rue, under the following title:—"Researches on Solar Physics, by Warren De la Rue, B. Stewart, and B. Loewy; first series; On the Nature of Sun-spots."

The present progress of the work of reduction will best be seen from the following letter, written by Mr. De la Rue, in answer to a request made through the Astronomer Royal by Padre Secchi, to know what was doing in this country in the subject of Heliography.

"110 Bunhill Row, August 8th, 1866.

"My dear Sir,—In reference to the extract from Padre Secchi's letter, I beg to supply the following information.

"The pictures taken by means of the Kew Heliograph are all measured by means of my Micrometer; the positions of the spots are then reduced to distances in terms (fractional parts) of the sun's radius, and the angles of position corrected for any error in the position of the wires.

"Pictures of the Pagoda are taken from time to time, and the measurements of the various galleries of the Pagoda serve to determine the optical distortion of the Sun's image, and the corrections to be applied to the Sun-pictures.

"The heliocentric latitudes and longitudes of the spots are then calculated.

"The areas of the spots and the penumbra are also measured, and the areas corrected for perspective are tabulated in terms (fractional parts) of the area of the sun's disk.

"The areas of the spots &c. on all of Carrington's original pictures have recently been measured, and an account of these measurements will be shortly published.

"Padre Secchi will be able to judge, from the foregoing statement, whether it will be worth while to undertake the work he proposes.

"The measurements obtainable from photographs are much more reliable than those from projected images. "I am,

"Yours very truly,

(Signed) "WARREN DE LA RUE."

"*E. J. Stone, Esq.*"

The Association will regret to learn the deaths of Dr. Sabler and M. Gussew, in consequence of which the Wilna Heliograph is not at work.

M. Smysloff of the Pulkowa Observatory has been appointed Director of the Wilna Observatory, by the Imperial Academy of Sciences of St. Petersburg. M. O. Struve having asked for information respecting the working of the Heliograph, it has been suggested to him by the Kew Committee that it would be advisable for M. Smysloff to visit the Kew Observatory, to see the instrument in operation.

The sun-spots continue to be observed after the method of Hofrath Schwabe, of Dessau, and the valuable collection of drawings lent by this eminent observer remains at the Observatory. These have been supplemented by the beautiful series of detailed drawings of spots made by the Rev. F. Howlett, which that gentleman has deposited at Kew.

The apparatus for verifying sextants alluded to in the last Report has now been constructed by Mr. Cooke, and is being erected at the Observatory.

About three-fourths of the region of the solar spectrum between E and F has been mapped by the spectroscope belonging to the Chairman. The spectroscope is now in London, the work appertaining to the staff at the Observatory not permitting sufficient time for further observation with this instrument.

The instrument devised by Mr. Broun for the purpose of estimating the magnetic dip by means of soft iron, remains at present at the Observatory, awaiting Mr. Broun's return to England.

The Superintendent has received grants from the Royal Society for special experiments; and when these are completed, an account will be rendered to that Society.

The Report of a Committee appointed to consider certain questions relating to the Meteorological Department of the Board of Trade, and presented to both Houses of Parliament by command of Her Majesty, has been communicated to the Members of the Kew Committee, and has been otherwise widely circulated among the meteorologists of the British Association: the object of the Report is expressed in the following terms:—

"Upon the death of the late Admiral FitzRoy, a correspondence took "place between the Board of Trade and the Royal Society with respect to "the Meteorological Department of the Board of Trade. The result of that "correspondence was the appointment of a Committee, consisting of the fol- "lowing gentlemen, viz. Francis Galton, Esq., F.R.S., General Secretary of the "British Association for the Advancement of Science, nominated by the Pre- "sident and Council of the Royal Society; Staff Commander Evans, R.N., "F.R.S., Chief Naval Assistant to the Hydrographer of the Admiralty, by "the Admiralty; T. H. Farrer, Esq., one of the Secretaries to the Board of "Trade, by the Board of Trade,—to consider and report upon the following "questions:—

"1. What are the data, especially as regards Meteorological Observations "at sea, already collected by and now existing in the Meteorological Depart- "ment of the Board of Trade?

"2. Whether any, and what steps should be taken for arranging, tabula-
"ting, publishing, or otherwise making use of such data.

"3. Whether it is desirable to continue Meteorological Observations at sea,
"and if so, to what extent, and in what manner.

"4. Assuming that the system of Weather Telegraphy is to be continued,
"can the mode of carrying it on and publishing the results be improved?

"5. What staff will be necessary for the above purposes?"

The authors of the Report arrive at the following conclusions in respect to the ocean statistics, weather telegraphy, foretelling weather, and observations affecting weather in the British Isles.

"The collection of observations from the captains of ships is a function
"which can probably best be performed through the medium of such agencies
"as a Government Office can command, and which was in fact well performed
"by the Meteorological Department before its attention was devoted to the
"practice of foretelling weather. We assume, therefore, that this function
"will remain with the Board of Trade.

"The digesting and tabulating results of observations is, on the other hand,
"a function which requires a large knowledge of what the state of the science
"for the time being requires, as well as exact scientific method.

"This function is one that has not been satisfactorily performed by the Me-
"teorological department. And we believe that it would be much better, as well
"as more economically performed, under the direction of a scientific body—
"such as a Committee of the Royal Society, or of the British Association, if
"furnished with the requisite funds by the Government—than it will be if
"left to a Government Department. The establishment already existing at
"Kew might probably be easily developed, so as to carry into effect such a
"purpose. It would in that case become a meteorological centre, to which
"all observations of value (by British observers), whether made on land or
"at sea, and whether within the British Isles or not, would be sent for dis-
"cussion and reduction. We have therefore in the following estimates, as-
"sumed that all meteorological observations made on land, whether at the
"stations recommended by the Royal Society, or at the lighthouses or coast
"guard stations, as well as all observations at sea, shall be referred to and
"discussed under the direction of such a scientific body as we have men-
"tioned; and we have also assumed that the aid afforded by Government
"would be in the shape of an annual vote, so made as to leave the Royal
"Society, or other scientific body charged with the duty, perfectly free in
"their method and in their choice of labour, but upon the condition that an
"account shall be rendered to Parliament of the money spent, and of the re-
"sults effected in each year."

The Kew Committee have examined this Report, and, speaking in general terms, they cordially acquiesce in the conclusions of its authors. They consider the proposed arrangement to fall within the competence of the Kew Observatory.

In the last Kew Report it was stated that many experiments and observations of a nature to advance science are made by the Committee under the sanction of the Association, the cost of each being defrayed by the promoters.

The Committee consider that the suggested observations contained in the Government Report which has been referred to, would be merely an extension of the usual practice of the Observatory; but in consideration of the magnitude of the work proposed, they suggest that the Council should bring the subject before the General Committee, with the view of the Kew Com-

mittee being authorized to discuss and make the necessary arrangements with the Board of Trade, should any proposal be made.

The Committee are also desirous of bringing under the consideration of the Council, the expediency of proceeding in the formation of a memoir on the periodic and non-periodic variations of the temperature at Kew, as a normal station of British meteorology. Similar works have for some years past occupied the attention of the most eminent amongst the continental meteorologists as being in fact the foundation of all *scientific* knowledge of the climatology of their respective countries. A memoir on the periodic and non-periodic variations of the temperature at the magnetical and meteorological observatory at Toronto in Canada has been printed in the Philosophical Transactions for 1853, but no such work has yet been systematically undertaken at Kew, although it is quite in accordance with the objects for which the Observatory was instituted, in familiarizing British meteorologists with a system of tabulation they have hitherto unduly neglected. Daily photograms taken from the thermograph constructed under Mr. Stewart's direction will supply in the most unexceptionable manner the observational basis on which the memoir would be founded.

To obtain such photograms would constitute a very small addition to the duties of the assistant by whom the daily photograms of the magnetical instruments are taken. The *tabulation* from the daily photograms of the temperature would be the only increase of any moment to the ordinary present work of the observatory, and would require, possibly, the part services of an additional young assistant.

The tabulation would supply twenty-four equidistant entries in every solar day. The tables containing these entries, together with the Photograms, after careful inspection by a proper authority, would be preserved for subsequent use. Five or, at most, six years would constitute quite a sufficient basis for the determination of the periodic variations forming the first part of the proposed work, and would require about a couple of months of superintending care on the part of the person who might be director of the Observatory, when the observations of the five or six years should have accumulated.

Nothing more than ordinary clerk's work under such general superintendence would be required.

Should the Board of Trade be disposed to avail itself of the suggestion which has been made to them in respect to the Kew Observatory, the publication which has been suggested would become one of its first important duties.

J. P. Gassiot,
*Chairman.*

Kew Observatory, August 17, 1866.

*Accounts of the Kew Committee of the British Association from September 6, 1865, to August 22, 1866.*

## RECEIPTS.

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| Balance from last account | | | | 26 | 14 | 8 |
| Received from the General Treasurer | | | | 600 | 0 | 0 |
| „ for the verification of Meteorological Instruments from the Board of Trade | 12 | 15 | 0 | | | |
| „ „ from the Admiralty | 14 | 15 | 0 | | | |
| „ „ from Opticians | 28 | 0 | 0 | | | |
| „ for Barograph Curves sent to the Meteorologic Office, London | 26 | 1 | 5 | | | |
| „ for the construction of standard Thermometers | 1 | 10 | 0 | | | |
| „ for the verification of portable Magnetometers | 15 | 0 | 0 | | | |
| „ for the verification of self-recording Magnetographs | 30 | 0 | 0 | | | |
| | | | | 128 | 1 | 5 |
| | | | | £754 | 16 | 1 |

## PAYMENTS.

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| Salaries, &c.:— | | | | | | |
| To B. Stewart, four quarters, ending 1st October, 1866 | 200 | 0 | 0 | | | |
| Ditto, allowed for petty travelling expenses | 10 | 0 | 0 | | | |
| G. Whipple, four quarters, ending 18th September, 1866 | 100 | 0 | 0 | | | |
| T. Baker, four quarters, ending 29th September, 1866 | 75 | 0 | 0 | | | |
| R. Beckley, 50 weeks, ending 20th August, 1866, at 40s. per week | 100 | 0 | 0 | | | |
| F. Page, 30 weeks, ending 2nd April, 1866, at 12s. per week | 18 | 0 | 0 | | | |
| Ditto, 2 quarters, ending 2nd October, 1866, at £40 per annum | 20 | 0 | 0 | | | |
| | | | | 523 | 0 | 0 |
| Apparatus, Materials, Tools, &c. | | | | 35 | 8 | 3 |
| Ironmonger, Carpenter, and Mason | | | | 18 | 6 | 3 |
| Printing, Stationery, Books, and Postage | | | | 36 | 15 | 10 |
| Coals and Gas | | | | 49 | 11 | 6 |
| House Expenses, Chandlery, &c. | | | | 30 | 5 | 3 |
| Porterage and petty expenses | | | | 18 | 16 | 3 |
| Rent of Land to 10th October, 1866 | | | | 11 | 0 | 0 |
| Rent of Pillars for Sextants | | | | 2 | 10 | 0 |
| Brushwood for ditch | | | | 6 | 13 | 0 |
| Balance | | | | 22 | 9 | 9 |
| | | | | £754 | 16 | 1 |

I have examined the above account and compared it with the vouchers presented to me.

| | £ | s. | d. |
|---|---|---|---|
| The Balance from the Last Year | 26 | 14 | 8 |
| Received from the Treasurer of the British Association | 600 | 0 | 0 |
| From Sundries, for the construction and verification of instruments | 128 | 1 | 5 |
| | 754 | 16 | 1 |
| The total Expenditure for the year | 732 | 6 | 4 |
| Leaving a balance in hand amounting to | £ 22 | 9 | 9 |

10*th August*, 1866.

R. HUTTON.

## *Report of the Parliamentary Committee to the Meeting of the British Association at Nottingham, August* 1866.

The Parliamentary Committee have the honour to report as follows:—

Your Committee have to express their regret that another Session of Parliament has been allowed to pass away without any step having been taken by the Legislature to promote the study of science in our great public schools.

In the last Session, however, an Act was passed to amend the Acts relating to the Imperial Standards of Weight, Measure, and Capacity.

The Act was introduced chiefly for the purpose of carrying out the recommendations of a Treasury Committee, which reported in 1864; and it will effect some very useful reforms in the constitution of the Office having the custody of the Imperial Standards, whereby the whole organization of the Department will be placed on a more scientific basis.

An Officer is appointed to be called the Warden of the Standards; and due provision is made for the periodical comparison of the Imperial and Secondary Standards, a matter which had hitherto been very much neglected. A provision is for the first time made for defining the amount of error to be tolerated in Secondary Standards; there is also a clause in which it is stated to be the duty of the Warden "to conduct all such comparisons, verifications, and other operations with reference to Standards of Length, Weight, and Capacity, in aid of scientific researches, or otherwise, as the Board of Trade from time to time authorize or direct."

Your Committee have also to express their regret that no steps have as yet been taken to reorganize the Meteorological Department of the Board of Trade, and carry out the valuable suggestions of the Report of Mr. Francis Galton and his colleagues, presented to Parliament during the last Session.

Your Committee will not fail to advocate such measures as may be necessary for placing this Department on a satisfactory footing. They will neither be unmindful of the part which they took in its original establishment, nor of the benefits which it has already conferred, and which, if successfully reorganized, it will continue to confer on Meteorological Science.

In conclusion, we recommend that Sir Henry Rawlinson be elected a Member of our Committee.

WROTTESLEY,
*Chairman.*

15th August, 1866.

## Recommendations adopted by the General Committee at the Nottingham Meeting in August 1866.

[When Committees are appointed, the Member first named is regarded as the Secretary, except there is a specific nomination.]

### *Involving Grants of Money.*

That the sum of £600 be placed at the disposal of the Council for maintaining the Establishment of the Kew Observatory.

That it would be conducive to the interest of science if opportunity were taken in connexion with the Indian Survey now in progress, to establish Astronomical and Meteorological Observations at a considerable height on the Himalaya; that for this purpose a powerful achromatic telescope and other instruments, should be placed at the disposal of the Superintendent of the Indian Survey; and that General Sabine, President of the Royal Society, Rev. C. Pritchard, President of the Royal Astronomical Society, The Lord Wrottesley, Professor Phillips, Mr. De la Rue, Mr. Huggins, and Mr. Brooke, with power to add to their number, be a Committee for the purpose of furthering this object; and that the sum of £200 be placed at their disposal for the purpose.

That the Lunar Committee be reappointed, and consist of Mr. J. Glaisher, Lord Rosse, Lord Wrottesley, Sir J. Herschel, Bart., Professor Phillips, Rev. C. Pritchard, Mr. W. Huggins, Mr. W. De la Rue, Mr. C. Brooke, Rev. T. W. Webb, Mr. J. N. Lockyer, and Mr. W. R. Birt; and that the sum of £120 be placed at their disposal.

That the Committee on Electrical Standards, consisting of Professor Williamson, Professor Wheatstone, Professor W. Thomson, Professor W. A. Miller, Dr. A. Matthiessen, Mr. Fleeming Jenkin, Sir Charles Bright, Professor Maxwell, Mr. C. W. Siemens, Mr. Balfour Stewart, Dr. Joule, and Mr. C. F. Varley, be reappointed, with the addition of Mr. G. C. Foster and Mr. C. Hockin; that Mr. Fleeming Jenkin be the Secretary, and that the sum of £100 be placed at their disposal.

That the Committee for the purpose of examining the late Dr. Rümker's Astronomical Observations in the Southern Hemisphere, consisting of the Astronomer Royal, Lord Wrottesley, Sir J. Herschel, Bart., Mr. W. De la Rue, and Mr. Glaisher (with power to add to their number), be reappointed; and that the grant of £150, which has lapsed, be renewed.

That the Committee, consisting of Mr. Glaisher, Lord Wrottesley, Professor Phillips, Mr. G. J. Symons, Mr. J. F. Bateman, and Mr. R. W. Mylne, be reappointed, for the purpose of continuing the Reports on the Rainfall of the British Isles; and that Mr. T. Hawksley be added to the Committee; that Mr. G. J. Symons be the Secretary, and that the sum of £50 be placed at their disposal.

That the Balloon Committee, consisting of Colonel Sykes, Mr. Airy, Lord Wrottesley, Sir David Brewster, Sir J. Herschel, Bart., Dr. Robinson, Mr. Fairbairn, Dr. Tyndall, Dr. W. A. Miller, and Mr. Glaisher, be reappointed; and that £50 (remaining undrawn of the grant of £100 made at Birmingham) be placed at their disposal.

That the Committee on Luminous Meteors and Aërolites, consisting of Mr. Glaisher, Mr. R. P. Greg, Mr. E. W. Brayley, and Mr. Alexander Herschel, be reappointed, with the addition of Mr. C. Brooke; that Mr.

Herschel be the Secretary, and that the sum of £50 be placed at their disposal for the purpose of publishing the list of radiant-points already determined.

That it is desirable to take advantage of the operations of the Palestine Exploration Fund for obtaining connected Meteorological Observations in Palestine; that a sum of £50 be placed at the disposal of the Kew Committee for providing the necessary instruments; and that the following gentlemen be a Committee to Report on the results: Mr. J. Glaisher, Lord Wrottesley, Mr. W. Spottiswoode, and Mr. G. Grove.

That the Committee for reporting on the Transmission of Sound under Water, consisting of Dr. Robinson, Professor Wheatstone, Dr. Gladstone, and Professor Hennessy, be reappointed (with power to add to their number); that Professor Hennessy be the Secretary; and that the sum of £30 be placed at their disposal for further experiments.

That Messrs. W. S. Mitchell, H. Woodward, and Mr. Robert Etheridge be a Committee for the purpose of continuing the investigations of the Alum Bay Leaf-Bed; and that the sum of £25 be placed at their disposal for the purpose.

That Sir Charles Lyell, Bart., Professor Phillips, Sir J. Lubbock, Bart., Mr. J. Evans, Mr. E. Vivian, Mr. W. Pengelly, and Mr. G. Busk, be a Committee for the purpose of continuing the exploration of Kent's Hole, Torquay; that Mr. Pengelly be the Secretary, and that the sum of £100 be placed at their disposal for the purpose.

That Mr. W. S. Mitchell, Mr. Robert Etheridge, and Professor Morris be a Committee for the purpose of investigating the Leaf-beds of Bournemouth and Corfe Castle; and that the Fossils obtained be placed at the disposal of the Curators of the Museum of Practical Geology for the purpose of their selecting a set for that Museum, and for the British Museum; that the sum of £30 be placed at their disposal for the purpose.

That Mr. Busk be appointed to aid the researches of Dr. Leith Adams on the Fossil Elephants of Malta; and that the sum of £50 be placed at his disposal for the purpose.

That Mr. C. Spence Bate and Professor Phillips be a Committee for the purpose of aiding Mr. Henry Woodward in his Researches on the Fossil Crustacea; and that the sum of £25 be placed at their disposal for the purpose.

That Dr. E. Perceval Wright and Professor Harkness be a Committee for the purpose of assisting Mr. W. B. Brownrigg in investigating the Fossil Fauna of the Kilkenny Coal-Fields; and that the sum of £25 be placed at their disposal for the purpose.

That Mr. Robert H. Scott, Dr. Hooker, Mr. E. H. Whymper, Dr. E. Perceval Wright, and Sir W. C. Trevelyan, Bart., be a Committee for the purpose of exploring the Plant-beds of North Greenland, and that a complete set of specimens be placed in the British Museum; and that the sum of £100 be placed at their disposal for the purpose.

That Professor Phillips, Professor Huxley, and Mr. H. G. Seeley be a Committee for the purpose of assisting in drawing up a Report on the present state of our knowledge of Secondary Reptiles, Pterodactyles, and Birds; and that the sum of £50 be placed at their disposal for the purpose.

That Mr. J. Gwyn Jeffreys, Mr. Edward Waller, Professor Wyville Thomson, and Dr. E. Perceval Wright be a Committee for the purpose of exploring the Marine Fauna of the North-west coast of Ireland; and that the sum of £25 be placed at their disposal for the purpose.

That Mr. J. Gwyn Jeffreys, Mr. R. McAndrew, Rev. A. Merle Norman, Mr. C. W. Peach, and Mr. R. Dawson be a Committee for the purpose of exploring the west coast of Shetland by means of the dredge; and that the sum of £75 be placed at their disposal for the purpose.

That Rev. H. B. Tristram, Sir John Lubbock, Bart., and Mr. H. T. Stainton be a Committee for the purpose of reporting on the Insect Fauna of Palestine; and that the sum of £30 be placed at their disposal for the purpose.

That Dr. E. Perceval Wright, Professor Newton, and Professor Rolleston be a Committee for the purpose of investigating the Flora and Fauna of the coast of North Greenland; and that the sum of £75 be placed at their disposal for the purpose.

That Dr. B. W. Richardson and Professor Humphry be a Committee for the purpose of continuing the investigations on the physiological action of the Ethyle and Methyle Series; and that the sum of £25 be placed at their disposal for the purpose.

That Sir Charles Nicholson, Bart., Sir Roderick Murchison, Bart., and Mr. Hogg be a Committee for the purpose of furthering the Palestine Explorations; that Mr. Hogg be the Secretary; and that the sum of £50 be placed at their disposal for the purpose.

That Sir John Bowring, The Right Hon. C. B. Adderley, Sir William Armstrong, Mr. Samuel Brown, Mr. W. Ewart, Dr. Farr, Mr. F. P. Fellows, The Right Hon. Earl Fortescue, Professor Frankland, Sir John Hay, Bart., Professor Hennessy, Mr. James Heywood, Sir Robert Kane, Dr. Leone Levi, Professor W. A. Miller, Professor Rankine, Mr. C. W. Siemens, Colonel Sykes, Mr. W. Tite, Professor W. A. Williamson, Lord Wrottesley, Mr. James Yates, Mr. Yates Thompson, Mr. Hendrick, and Dr. George Glover be a Committee for the purpose of diffusing knowledge of the Decimal and Metric System of Moneys, Weights, and Measures, and that the same be requested to put themselves in communication with the International Statistical Congress to be held in Florence, when the adoption of a Common System of Moneys, Weights, and Measures is likely to be discussed; that Professor Leone Levi be the Secretary, and that the sum of £30 be placed at their disposal for the purpose.

That Mr. J. Scott Russell, Mr. T. Hawksley, Mr. J. R. Napier, Mr. William Fairbairn, and Professor W. J. M. Rankine be a Committee to analyze and condense the information contained in the Reports of the "Steam-ship Performance" Committee and other sources of information on the same subject, with power to employ paid calculators or assistants, if necessary; and that the sum of £100 be placed at their disposal for the purpose.

That the Committee on the Patent Laws, consisting of Mr. Thomas Webster, Sir W. G. Armstrong, Mr. J. F. Bateman, Mr. John Hawkshaw, Mr. J. Scott Russell, Mr. W. Fairbairn, Mr. John Bethel, and Mr. P. Le Neve Foster, be reappointed; and that the grant of £30, not drawn, be renewed.

That Mr. Fairbairn and Mr. Tait be a Committee for continuing experiments with a view to test the improvements in the manufacture of iron and steel; and that the sum of £25 be placed at their disposal for the purpose.

### *Applications for Reports and Researches not involving Grants of Money.*

That the Rev. Professor Harley be requested to undertake an inquiry into the validity of the method proposed by the late Judge Hargreave for the resolution of Algebraic Equations, and to report thereon.

That Dr. Matthiessen be requested to continue his researches on the Chemical Constitution of Cast Iron.

That Dr. Paul be requested to continue his researches on the Application of Chemistry to Geology.

That Professor Wanklyn be requested to continue his researches on the Isomeric Alcohols.

That Mr. Thomas Fairley be requested to continue his researches on Polycyanides of Organic Radicals.

That Dr. Baker Edwards be requested to continue his researches on the Alkaloidal Principles of the Calabar Bean.

That Mr. J. Gwyn Jeffreys, Dr. Collingwood, Rev. H. H. Higgins, Mr. Isaac Byerley, Dr. J. B. Edwards, and Mr. Thomas J. Moore be reappointed for the purpose of dredging the Estuary of the Mersey.

That Mr. J. Gwyn Jeffreys, Mr. C. Spence Bate, Mr. Jonathan Couch, Mr. C. Stewart, Rev. Thomas Hincks, and Mr. B. Rowe be reappointed a Committee for the purpose of investigating the Marine Fauna and Flora of the coasts of Devon and Cornwall; and that Mr. C. Spence Bate be the Secretary.

That Mr. J. Gwyn Jeffreys, Dr. J. E. Gray, Mr. R. M'Andrew, Mr. C. Spence Bate, Rev. A. Merle Norman, Dr. E. Perceval Wright, and the Rev. Thomas Hincks be a Committee for the purpose of superintending the various Committees appointed by the British Association to dredge in the British Seas.

That the Committee on Scientific Evidence in Courts of Law, consisting of the Rev. W. V. Harcourt, Professor Williamson, The Right Hon. J. Napier, Mr. W. Tite, Professor Christison, Mr. Carpmael, Dr. Tyndall, Mr. James Heywood, Mr. J. F. Bateman, Mr. Thomas Webster, Sir Benjamin Brodie, Bart., and Professor W. A. Miller (with power to add to their number), be reappointed; and that Professor Williamson be the Secretary.

That the Committee to arrange and analyze the Tidal Observations which have already been made on the coasts and estuaries of Great Britain, and to make such further observations and investigations as the Committee may deem desirable for recording and exhibiting Tidal Phenomena, be reappointed, and that temperature be included in these observations; such Committee to consist of Mr. J. Hawkshaw, Mr. J. F. Bateman, Mr. J. Oldham, Mr. W. Parkes, Mr. J. Scott Russell, Mr. T. Webster, Mr. C. Vignoles, Sir J. Rennie, Mr. W. Sissons, Mr. G. P. Bidder, jun., with Mr. J. F. Iselin as Secretary.

### *Involving Application to Government.*

That Sir Roderick Murchison, Bart., Lieut.-General Sabine, Admiral Ommanney, Admiral Collinson, and Mr. Markham be a Committee for the purpose of representing to Her Majesty's Government the importance to Science of a further exploration of the North Polar Regions; and that Mr. Markham be the Secretary.

That the Kew Committee be authorized to discuss and make the necessary arrangements with the Board of Trade, should any proposal be made respecting the superintendence, reduction, and publication of Meteorological Observations, in accordance with the recommendations of the Report of the Committee appointed to consider certain questions relating to the Meteorological Department of the Board of Trade.

### *Communications to be printed in extenso.*

That Professor Matteucci's letter to the President be printed entire in the Reports of the Association.

That Captain Noble's paper "On the Penetration of Shot and resistance of Iron-clad Defences" be printed *in extenso* in the Reports.

***Synopsis of Grants of Money appropriated to Scientific Purposes by the General Committee at the Nottingham Meeting in August 1866. The names of the Members who would be entitled to call on the General Treasurer for the respective Grants are prefixed.***

| | £ | s. | d. |
|---|---|---|---|
| *Kew Observatory.* | | | |
| Maintaining the Establishment of Kew Observatory ..... | 600 | 0 | 0 |
| *Mathematics and Physics.* | | | |
| Sabine, Lieut.-General.—Instruments for observations in India | 200 | 0 | 0 |
| Glaisher, Mr.—Lunar Committee ..... | 120 | 0 | 0 |
| Williamson, Prof.—Electrical Standards ..... | 100 | 0 | 0 |
| Airy, Mr.—Reduction of Rümker's Observations (renewed) .. | 150 | 0 | 0 |
| Glaisher, Mr.—British Rainfall ..... | 50 | 0 | 0 |
| Sykes, Col.—Balloon Experiments ..... | 50 | 0 | 0 |
| Glaisher, Mr.—Luminous Meteors ..... | 50 | 0 | 0 |
| Kew Committee.—Meteorological observations in Palestine .. | 50 | 0 | 0 |
| Robinson, Dr.—Sound under Water ..... | 30 | 0 | 0 |
| *Geology.* | | | |
| Mitchell, Mr.—Alum Bay Fossil Leaf-Beds..... | 25 | 0 | 0 |
| Lyell, Sir C.—Kent's Hole Investigation ..... | 100 | 0 | 0 |
| Mitchell, Mr.—Bournemouth Fossil Leaf-Beds ..... | 30 | 0 | 0 |
| Busk, Professor.—Maltese Caverns Elephants ..... | 50 | 0 | 0 |
| Bate, Mr. C. Spence.—Fossil Crustacea ..... | 25 | 0 | 0 |
| Wright, Dr. E. P.—Kilkenny Coal-field ..... | 25 | 0 | 0 |
| Scott, Mr. R. H.—Plant Beds of North Greenland ..... | 100 | 0 | 0 |
| Phillips, Prof.—Secondary Reptiles ..... | 50 | 0 | 0 |
| *Biology.* | | | |
| Jeffreys, Mr.—Marine Fauna, Ireland ..... | 25 | 0 | 0 |
| Jeffreys, Mr.—Dredging West Coast of Shetland ..... | 75 | 0 | 0 |
| Tristram, Rev. H. B.—Insect Fauna, Palestine ..... | 30 | 0 | 0 |
| Wright, Dr. E. P.—Coast of North Greenland, Flora and Fauna | 75 | 0 | 0 |
| Richardson, Dr. B. W.—Physiological action of the Ethyl and Methyl Series ..... | 25 | 0 | 0 |
| *Geography and Ethnology.* | | | |
| Nicholson, Sir C.—Palestine Exploration ..... | 50 | 0 | 0 |
| *Statistics and Economic Science.* | | | |
| Bowring, Sir J.—Metrical Committee ..... | 30 | 0 | 0 |
| *Mechanics.* | | | |
| Russell, Mr. J. Scott.—Analysis of Reports on Steam-ship Performance ..... | 100 | 0 | 0 |
| Fairbairn, Mr.—Manufacture of Iron and Steel ..... | 25 | 0 | 0 |
| Webster, Mr.—Patent Laws (renewed) ..... | 30 | 0 | 0 |
| Total..... | 2270 | 0 | 0 |

## *General Statement of Sums which have been paid on Account of Grants for Scientific Purposes.*

| | £ | s. | d. |
|---|---|---|---|
| **1834.** | | | |
| Tide Discussions | 20 | 0 | 0 |
| **1835.** | | | |
| Tide Discussions | 62 | 0 | 0 |
| British Fossil Ichthyology | 105 | 0 | 0 |
| | £167 | 0 | 0 |
| **1836.** | | | |
| Tide Discussions | 163 | 0 | 0 |
| British Fossil Ichthyology | 105 | 0 | 0 |
| Thermometric Observations, &c. | 50 | 0 | 0 |
| Experiments on long-continued Heat | 17 | 1 | 0 |
| Rain-Gauges | 9 | 13 | 0 |
| Refraction Experiments | 15 | 0 | 0 |
| Lunar Nutation | 60 | 0 | 0 |
| Thermometers | 15 | 6 | 0 |
| | £434 | 14 | 0 |
| **1837.** | | | |
| Tide Discussions | 284 | 1 | 0 |
| Chemical Constants | 24 | 13 | 6 |
| Lunar Nutation | 70 | 0 | 0 |
| Observations on Waves | 100 | 12 | 0 |
| Tides at Bristol | 150 | 0 | 0 |
| Meteorology and Subterranean Temperature | 89 | 5 | 0 |
| Vitrification Experiments | 150 | 0 | 0 |
| Heart Experiments | 8 | 4 | 6 |
| Barometric Observations | 30 | 0 | 0 |
| Barometers | 11 | 18 | 6 |
| | £918 | 14 | 6 |
| **1838.** | | | |
| Tide Discussions | 29 | 0 | 0 |
| British Fossil Fishes | 100 | 0 | 0 |
| Meteorological Observations and Anemometer (construction) | 100 | 0 | 0 |
| Cast Iron (Strength of) | 60 | 0 | 0 |
| Animal and Vegetable Substances (Preservation of) | 19 | 1 | 10 |
| Railway Constants | 41 | 12 | 10 |
| Bristol Tides | 50 | 0 | 0 |
| Growth of Plants | 75 | 0 | 0 |
| Mud in Rivers | 3 | 6 | 6 |
| Education Committee | 50 | 0 | 0 |
| Heart Experiments | 5 | 3 | 0 |
| Land and Sea Level | 267 | 8 | 7 |
| Subterranean Temperature | 8 | 6 | 0 |
| Steam-vessels | 100 | 0 | 0 |
| Meteorological Committee | 31 | 9 | 5 |
| Thermometers | 16 | 4 | 0 |
| | £956 | 12 | 2 |
| **1839.** | | | |
| Fossil Ichthyology | 110 | 0 | 0 |
| Meteorological Observations at Plymouth | 63 | 10 | 0 |
| Mechanism of Waves | 144 | 2 | 0 |
| Bristol Tides | 35 | 18 | 6 |
| Meteorology and Subterranean Temperature | 21 | 11 | 0 |
| Vitrification Experiments | 9 | 4 | 7 |
| Cast Iron Experiments | 100 | 0 | 0 |
| Railway Constants | 28 | 7 | 2 |
| Land and Sea Level | 274 | 1 | 4 |
| Steam-vessels' Engines | 100 | 0 | 0 |
| Stars in Histoire Céleste | 331 | 18 | 6 |
| Stars in Lacaille | 11 | 0 | 0 |
| Stars in R.A.S. Catalogue | 6 | 16 | 6 |
| Animal Secretions | 10 | 10 | 0 |
| Steam-engines in Cornwall | 50 | 0 | 0 |
| Atmospheric Air | 16 | 1 | 0 |
| Cast and Wrought Iron | 40 | 0 | 0 |
| Heat on Organic Bodies | 3 | 0 | 0 |
| Gases on Solar Spectrum | 22 | 0 | 0 |
| Hourly Meteorological Observations, Inverness and Kingussie | 49 | 7 | 8 |
| Fossil Reptiles | 118 | 2 | 9 |
| Mining Statistics | 50 | 0 | 0 |
| | £1595 | 11 | 0 |
| **1840.** | | | |
| Bristol Tides | 100 | 0 | 0 |
| Subterranean Temperature | 13 | 13 | 6 |
| Heart Experiments | 18 | 19 | 0 |
| Lungs Experiments | 8 | 13 | 0 |
| Tide Discussions | 50 | 0 | 0 |
| Land and Sea Level | 6 | 11 | 1 |
| Stars (Histoire Céleste) | 242 | 10 | 0 |
| Stars (Lacaille) | 4 | 15 | 0 |
| Stars (Catalogue) | 264 | 0 | 0 |
| Atmospheric Air | 15 | 15 | 0 |
| Water on Iron | 10 | 0 | 0 |
| Heat on Organic Bodies | 7 | 0 | 0 |
| Meteorological Observations | 52 | 17 | 6 |
| Foreign Scientific Memoirs | 112 | 1 | 6 |
| Working Population | 100 | 0 | 0 |
| School Statistics | 50 | 0 | 0 |
| Forms of Vessels | 184 | 7 | 0 |
| Chemical and Electrical Phenomena | 40 | 0 | 0 |
| Meteorological Observations at Plymouth | 80 | 0 | 0 |
| Magnetical Observations | 185 | 13 | 9 |
| | £1546 | 16 | 4 |
| **1841.** | | | |
| Observations on Waves | 30 | 0 | 0 |
| Meteorology and Subterranean Temperature | 8 | 8 | 0 |
| Actinometers | 10 | 0 | 0 |
| Earthquake Shocks | 17 | 7 | 0 |
| Acrid Poisons | 6 | 0 | 0 |
| Veins and Absorbents | 3 | 0 | 0 |
| Mud in Rivers | 5 | 0 | 0 |
| Marine Zoology | 15 | 12 | 8 |
| Skeleton Maps | 20 | 0 | 0 |
| Mountain Barometers | 6 | 18 | 6 |
| Stars (Histoire Céleste) | 185 | 0 | 0 |

| | £ | s. | d. |
|---|---|---|---|
| Stars (Lacaille) | 79 | 5 | 0 |
| Stars (Nomenclature of) | 17 | 19 | 6 |
| Stars (Catalogue of) | 40 | 0 | 0 |
| Water on Iron | 50 | 0 | 0 |
| Meteorological Observations at Inverness | 20 | 0 | 0 |
| Meteorological Observations (reduction of) | 25 | 0 | 0 |
| Fossil Reptiles | 50 | 0 | 0 |
| Foreign Memoirs | 62 | 0 | 0 |
| Railway Sections | 38 | 1 | 6 |
| Forms of Vessels | 193 | 12 | 0 |
| Meteorological Observations at Plymouth | 55 | 0 | 0 |
| Magnetical Observations | 61 | 18 | 8 |
| Fishes of the Old Red Sandstone | 100 | 0 | 0 |
| Tides at Leith | 50 | 0 | 0 |
| Anemometer at Edinburgh | 69 | 1 | 10 |
| Tabulating Observations | 9 | 6 | 3 |
| Races of Men | 5 | 0 | 0 |
| Radiate Animals | 2 | 0 | 0 |
| | £1235 | 10 | 11 |

1842.

| | | | |
|---|---|---|---|
| Dynamometric Instruments | 113 | 11 | 2 |
| Anoplura Britanniæ | 52 | 12 | 0 |
| Tides at Bristol | 59 | 8 | 0 |
| Gases on Light | 30 | 14 | 7 |
| Chronometers | 26 | 17 | 6 |
| Marine Zoology | 1 | 5 | 0 |
| British Fossil Mammalia | 100 | 0 | 0 |
| Statistics of Education | 20 | 0 | 0 |
| Marine Steam-vessels' Engines | 28 | 0 | 0 |
| Stars (Histoire Céleste) | 59 | 0 | 0 |
| Stars (Brit. Assoc. Cat. of) | 110 | 0 | 0 |
| Railway Sections | 161 | 10 | 0 |
| British Belemnites | 50 | 0 | 0 |
| Fossil Reptiles (publication of Report) | 210 | 0 | 0 |
| Forms of Vessels | 180 | 0 | 0 |
| Galvanic Experiments on Rocks | 5 | 8 | 6 |
| Meteorological Experiments at Plymouth | 68 | 0 | 0 |
| Constant Indicator and Dynamometric Instruments | 90 | 0 | 0 |
| Force of Wind | 10 | 0 | 0 |
| Light on Growth of Seeds | 8 | 0 | 0 |
| Vital Statistics | 50 | 0 | 0 |
| Vegetative Power of Seeds | 8 | 1 | 11 |
| Questions on Human Race | 7 | 9 | 0 |
| | £1449 | 17 | 8 |

1843.

| | | | |
|---|---|---|---|
| Revision of the Nomenclature of Stars | 2 | 0 | 0 |
| Reduction of Stars, British Association Catalogue | 25 | 0 | 0 |
| Anomalous Tides, Frith of Forth | 120 | 0 | 0 |
| Hourly Meteorological Observations at Kingussie and Inverness | 77 | 12 | 8 |
| Meteorological Observations at Plymouth | 55 | 0 | 0 |
| Whewell's Meteorological Anemometer at Plymouth | 10 | 0 | 0 |
| Meteorological Observations, Osler's Anemometer at Plymouth | 20 | 0 | 0 |
| Reduction of Meteorological Observations | 30 | 0 | 0 |
| Meteorological Instruments and Gratuities | 39 | 6 | 0 |
| Construction of Anemometer at Inverness | 56 | 12 | 2 |
| Magnetic Cooperation | 10 | 8 | 10 |
| Meteorological Recorder for Kew Observatory | 50 | 0 | 0 |
| Action of Gases on Light | 18 | 16 | 1 |
| Establishment at Kew Observatory, Wages, Repairs, Furniture and Sundries | 133 | 4 | 7 |
| Experiments by Captive Balloons | 81 | 8 | 0 |
| Oxidation of the Rails of Railways | 20 | 0 | 0 |
| Publication of Report on Fossil Reptiles | 40 | 0 | 0 |
| Coloured Drawings of Railway Sections | 147 | 18 | 3 |
| Registration of Earthquake Shocks | 30 | 0 | 0 |
| Report on Zoological Nomenclature | 10 | 0 | 0 |
| Uncovering Lower Red Sandstone near Manchester | 4 | 4 | 6 |
| Vegetative Power of Seeds | 5 | 3 | 8 |
| Marine Testacea (Habits of) | 10 | 0 | 0 |
| Marine Zoology | 10 | 0 | 0 |
| Marine Zoology | 2 | 14 | 11 |
| Preparation of Report on British Fossil Mammalia | 100 | 0 | 0 |
| Physiological Operations of Medicinal Agents | 20 | 0 | 0 |
| Vital Statistics | 36 | 5 | 8 |
| Additional Experiments on the Forms of Vessels | 70 | 0 | 0 |
| Additional Experiments on the Forms of Vessels | 100 | 0 | 0 |
| Reduction of Experiments on the Forms of Vessels | 100 | 0 | 0 |
| Morin's Instrument and Constant Indicator | 69 | 14 | 10 |
| Experiments on the Strength of Materials | 60 | 0 | 0 |
| | £1565 | 10 | 2 |

1844.

| | | | |
|---|---|---|---|
| Meteorological Observations at Kingussie and Inverness | 12 | 0 | 0 |
| Completing Observations at Plymouth | 85 | 0 | 0 |
| Magnetic and Meteorological Cooperation | 25 | 8 | 4 |
| Publication of the British Association Catalogue of Stars | 35 | 0 | 0 |
| Observations on Tides on the East coast of Scotland | 100 | 0 | 0 |
| Revision of the Nomenclature of Stars ....1842 | 2 | 9 | 6 |
| Maintaining the Establishment in Kew Observatory | 117 | 17 | 3 |
| Instruments for Kew Observatory | 56 | 7 | 3 |

| | £ | s. | d. |
|---|---|---|---|
| Influence of Light on Plants..... | 10 | 0 | 0 |
| Subterraneous Temperature in Ireland ..... | 5 | 0 | 0 |
| Coloured Drawings of Railway Sections ..... | 15 | 17 | 6 |
| Investigation of Fossil Fishes of the Lower Tertiary Strata ... | 100 | 0 | 0 |
| Registering the Shocks of Earthquakes .....1842 | 23 | 11 | 10 |
| Structure of Fossil Shells ..... | 20 | 0 | 0 |
| Radiata and Mollusca of the Ægean and Red Seas.....1842 | 100 | 0 | 0 |
| Geographical Distributions of Marine Zoology.....1842 | 0 | 10 | 0 |
| Marine Zoology of Devon and Cornwall ..... | 10 | 0 | 0 |
| Marine Zoology of Corfu ..... | 10 | 0 | 0 |
| Experiments on the Vitality of Seeds ..... | 9 | 0 | 3 |
| Experiments on the Vitality of Seeds .....1842 | 8 | 7 | 3 |
| Exotic Anoplura ..... | 15 | 0 | 0 |
| Strength of Materials ..... | 100 | 0 | 0 |
| Completing Experiments on the Forms of Ships ..... | 100 | 0 | 0 |
| Inquiries into Asphyxia ..... | 10 | 0 | 0 |
| Investigations on the Internal Constitution of Metals ..... | 50 | 0 | 0 |
| Constant Indicator and Morin's Instrument, 1842 ..... | 10 | 3 | 6 |
| | £981 | 12 | 8 |

1845.

| | | | |
|---|---|---|---|
| Publication of the British Association Catalogue of Stars ..... | 351 | 14 | 6 |
| Meteorological Observations at Inverness ..... | 30 | 18 | 11 |
| Magnetic and Meteorological Co-operation ..... | 16 | 16 | 8 |
| Meteorological Instruments at Edinburgh..... | 18 | 11 | 9 |
| Reduction of Anemometrical Observations at Plymouth ..... | 25 | 0 | 0 |
| Electrical Experiments at Kew Observatory ..... | 43 | 17 | 8 |
| Maintaining the Establishment in Kew Observatory ..... | 149 | 15 | 0 |
| For Krell's Barometrograph ..... | 25 | 0 | 0 |
| Gases from Iron Furnaces ..... | 50 | 0 | 0 |
| The Actinograph ..... | 15 | 0 | 0 |
| Microscopic Structure of Shells... | 20 | 0 | 0 |
| Exotic Anoplura .....1843 | 10 | 0 | 0 |
| Vitality of Seeds.....1843 | 2 | 0 | 7 |
| Vitality of Seeds.....1844 | 7 | 0 | 0 |
| Marine Zoology of Cornwall..... | 10 | 0 | 0 |
| Physiological Action of Medicines | 20 | 0 | 0 |
| Statistics of Sickness and Mortality in York ..... | 20 | 0 | 0 |
| Earthquake Shocks .....1843 | 15 | 14 | 8 |
| | £830 | 9 | 9 |

1846.

| | | | |
|---|---|---|---|
| British Association Catalogue of Stars .....1844 | 211 | 15 | 0 |
| Fossil Fishes of the London Clay | 100 | 0 | 0 |
| Computation of the Gaussian Constants for 1839..... | 50 | 0 | 0 |
| Maintaining the Establishment at Kew Observatory ..... | 146 | 16 | 7 |
| Strength of Materials..... | 60 | 0 | 0 |
| Researches in Asphyxia..... | 6 | 16 | 2 |
| Examination of Fossil Shells..... | 10 | 0 | 0 |
| Vitality of Seeds .....1844 | 2 | 15 | 10 |
| Vitality of Seeds .....1845 | 7 | 12 | 3 |
| Marine Zoology of Cornwall..... | 10 | 0 | 0 |
| Marine Zoology of Britain ..... | 10 | 0 | 0 |
| Exotic Anoplura .....1844 | 25 | 0 | 0 |
| Expenses attending Anemometers | 11 | 7 | 6 |
| Anemometers' Repairs ..... | 2 | 3 | 6 |
| Atmospheric Waves ..... | 3 | 3 | 3 |
| Captive Balloons .....1844 | 8 | 19 | 3 |
| Varieties of the Human Race 1844 | 7 | 6 | 3 |
| Statistics of Sickness and Mortality in York ..... | 12 | 0 | 0 |
| | £685 | 16 | 0 |

1847.

| | | | |
|---|---|---|---|
| Computation of the Gaussian Constants for 1839 ..... | 50 | 0 | 0 |
| Habits of Marine Animals ..... | 10 | 0 | 0 |
| Physiological Action of Medicines | 20 | 0 | 0 |
| Marine Zoology of Cornwall ... | 10 | 0 | 0 |
| Atmospheric Waves ..... | 6 | 9 | 3 |
| Vitality of Seeds ..... | 4 | 7 | 7 |
| Maintaining the Establishment at Kew Observatory ..... | 107 | 8 | 6 |
| | £208 | 5 | 4 |

1848.

| | | | |
|---|---|---|---|
| Maintaining the Establishment at Kew Observatory ..... | 171 | 15 | 11 |
| Atmospheric Waves ..... | 3 | 10 | 9 |
| Vitality of Seeds ..... | 9 | 15 | 0 |
| Completion of Catalogues of Stars | 70 | 0 | 0 |
| On Colouring Matters ..... | 5 | 0 | 0 |
| On Growth of Plants..... | 15 | 0 | 0 |
| | £275 | 1 | 8 |

1849.

| | | | |
|---|---|---|---|
| Electrical Observations at Kew Observatory ..... | 50 | 0 | 0 |
| Maintaining Establishment at ditto ..... | 76 | 2 | 5 |
| Vitality of Seeds ..... | 5 | 8 | 1 |
| On Growth of Plants..... | 5 | 0 | 0 |
| Registration of Periodical Phenomena ..... | 10 | 0 | 0 |
| Bill on account of Anemometrical Observations ..... | 13 | 9 | 0 |
| | £159 | 19 | 6 |

1850.

| | | | |
|---|---|---|---|
| Maintaining the Establishment at Kew Observatory ..... | 255 | 18 | 0 |
| Transit of Earthquake Waves ... | 50 | 0 | 0 |

| | £ | s. | d. |
|---|---|---|---|
| Periodical Phenomena | 15 | 0 | 0 |
| Meteorological Instrument, Azores | 25 | 0 | 0 |
| | £345 | 18 | 0 |

1851.

| | | | |
|---|---|---|---|
| Maintaining the Establishment at Kew Observatory (includes part of grant in 1849) | 309 | 2 | 2 |
| Theory of Heat | 20 | 1 | 1 |
| Periodical Phenomena of Animals and Plants | 5 | 0 | 0 |
| Vitality of Seeds | 5 | 6 | 4 |
| Influence of Solar Radiation | 30 | 0 | 0 |
| Ethnological Inquiries | 12 | 0 | 0 |
| Researches on Annelida | 10 | 0 | 0 |
| | £391 | 9 | 7 |

1852.

| | | | |
|---|---|---|---|
| Maintaining the Establishment at Kew Observatory (including balance of grant for 1850) | 233 | 17 | 8 |
| Experiments on the Conduction of Heat | 5 | 2 | 9 |
| Influence of Solar Radiations | 20 | 0 | 0 |
| Geological Map of Ireland | 15 | 0 | 0 |
| Researches on the British Annelida | 10 | 0 | 0 |
| Vitality of Seeds | 10 | 6 | 2 |
| Strength of Boiler Plates | 10 | 0 | 0 |
| | £304 | 6 | 7 |

1853.

| | | | |
|---|---|---|---|
| Maintaining the Establishment at Kew Observatory | 165 | 0 | 0 |
| Experiments on the Influence of Solar Radiation | 15 | 0 | 0 |
| Researches on the British Annelida | 10 | 0 | 0 |
| Dredging on the East Coast of Scotland | 10 | 0 | 0 |
| Ethnological Queries | 5 | 0 | 0 |
| | £205 | 0 | 0 |

1854.

| | | | |
|---|---|---|---|
| Maintaining the Establishment at Kew Observatory (including balance of former grant) | 330 | 15 | 4 |
| Investigations on Flax | 11 | 0 | 0 |
| Effects of Temperature on Wrought Iron | 10 | 0 | 0 |
| Registration of Periodical Phenomena | 10 | 0 | 0 |
| British Annelida | 10 | 0 | 0 |
| Vitality of Seeds | 5 | 2 | 3 |
| Conduction of Heat | 4 | 2 | 0 |
| | £380 | 19 | 7 |

1855.

| | | | |
|---|---|---|---|
| Maintaining the Establishment at Kew Observatory | 425 | 0 | 0 |
| Earthquake Movements | 10 | 0 | 0 |
| Physical Aspect of the Moon | 11 | 8 | 5 |
| Vitality of Seeds | 10 | 7 | 11 |
| Map of the World | 15 | 0 | 0 |
| Ethnological Queries | 5 | 0 | 0 |
| Dredging near Belfast | 4 | 0 | 0 |
| | £480 | 16 | 4 |

| | £ | s. | d. |
|---|---|---|---|
| 1856. | | | |
| Maintaining the Establishment at Kew Observatory:— 1854.....£ 75 0 0 1855.....£500 0 0 | 575 | 0 | 0 |
| Strickland's Ornithological Synonyms | 100 | 0 | 0 |
| Dredging and Dredging Forms | 9 | 13 | 9 |
| Chemical Action of Light | 20 | 0 | 0 |
| Strength of Iron Plates | 10 | 0 | 0 |
| Registration of Periodical Phenomena | 10 | 0 | 0 |
| Propagation of Salmon | 10 | 0 | 0 |
| | £734 | 13 | 9 |

1857.

| | | | |
|---|---|---|---|
| Maintaining the Establishment at Kew Observatory | 350 | 0 | 0 |
| Earthquake Wave Experiments | 40 | 0 | 0 |
| Dredging near Belfast | 10 | 0 | 0 |
| Dredging on the West Coast of Scotland | 10 | 0 | 0 |
| Investigations into the Mollusca of California | 10 | 0 | 0 |
| Experiments on Flax | 5 | 0 | 0 |
| Natural History of Madagascar | 20 | 0 | 0 |
| Researches on British Annelida | 25 | 0 | 0 |
| Report on Natural Products imported into Liverpool | 10 | 0 | 0 |
| Artificial Propagation of Salmon | 10 | 0 | 0 |
| Temperature of Mines | 7 | 8 | 0 |
| Thermometers for Subterranean Observations | 5 | 7 | 4 |
| Life-Boats | 5 | 0 | 0 |
| | £507 | 15 | 4 |

1858.

| | | | |
|---|---|---|---|
| Maintaining the Establishment at Kew Observatory | 500 | 0 | 0 |
| Earthquake Wave Experiments | 25 | 0 | 0 |
| Dredging on the West Coast of Scotland | 10 | 0 | 0 |
| Dredging near Dublin | 5 | 0 | 0 |
| Vitality of Seeds | 5 | 5 | 0 |
| Dredging near Belfast | 18 | 13 | 2 |
| Report on the British Annelida | 25 | 0 | 0 |
| Experiments on the production of Heat by Motion in Fluids | 20 | 0 | 0 |
| Report on the Natural Products Imported into Scotland | 10 | 0 | 0 |
| | £618 | 18 | 2 |

1859.

| | | | |
|---|---|---|---|
| Maintaining the Establishment at Kew Observatory | 500 | 0 | 0 |
| Dredging near Dublin | 15 | 0 | 0 |
| Osteology of Birds | 50 | 0 | 0 |
| Irish Tunicata | 5 | 0 | 0 |
| Manure Experiments | 20 | 0 | 0 |
| British Medusidæ | 5 | 0 | 0 |
| Dredging Committee | 5 | 0 | 0 |
| Steam-vessels' Performance | 5 | 0 | 0 |
| Marine Fauna of South and West of Ireland | 10 | 0 | 0 |
| Photographic Chemistry | 10 | 0 | 0 |
| Lanarkshire Fossils | 20 | 0 | 1 |
| Balloon Ascents | 39 | 11 | 0 |
| | £684 | 11 | 1 |

| 1860. | £ | s. | d. |
|---|---|---|---|
| Maintaining the Establishment of Kew Observatory | 500 | 0 | 0 |
| Dredging near Belfast | 16 | 6 | 0 |
| Dredging in Dublin Bay | 15 | 0 | 0 |
| Inquiry into the Performance of Steam-vessels | 124 | 0 | 0 |
| Explorations in the Yellow Sandstone of Dura Den | 20 | 0 | 0 |
| Chemico-mechanical Analysis of Rocks and Minerals | 25 | 0 | 0 |
| Researches on the Growth of Plants | 10 | 0 | 0 |
| Researches on the Solubility of Salts | 30 | 0 | 0 |
| Researches on the Constituents of Manures | 25 | 0 | 0 |
| Balance of Captive Balloon Accounts | 1 | 13 | 6 |
| | £1241 | 7 | 0 |

| 1861. | £ | s. | d. |
|---|---|---|---|
| Maintaining the Establishment of Kew Observatory | 500 | 0 | 0 |
| Earthquake Experiments | 25 | 0 | 0 |
| Dredging North and East Coasts of Scotland | 23 | 0 | 0 |
| Dredging Committee:— 1860 ..... £50 0 0 / 1861 ..... £22 0 0 | 72 | 0 | 0 |
| Excavations at Dura Den | 20 | 0 | 0 |
| Solubility of Salts | 20 | 0 | 0 |
| Steam-vessel Performance | 150 | 0 | 0 |
| Fossils of Lesmahago | 15 | 0 | 0 |
| Explorations at Uriconium | 20 | 0 | 0 |
| Chemical Alloys | 20 | 0 | 0 |
| Classified Index to the Transactions | 100 | 0 | 0 |
| Dredging in the Mersey and Dee | 5 | 0 | 0 |
| Dip Circle | 30 | 0 | 0 |
| Photoheliographic Observations | 50 | 0 | 0 |
| Prison Diet | 20 | 0 | 0 |
| Gauging of Water | 10 | 0 | 0 |
| Alpine Ascents | 6 | 5 | 1 |
| Constituents of Manures | 25 | 0 | 0 |
| | £1111 | 5 | 10 |

| 1862. | £ | s. | d. |
|---|---|---|---|
| Maintaining the Establishment of Kew Observatory | 500 | 0 | 0 |
| Patent Laws | 21 | 6 | 0 |
| Mollusca of N.-W. America | 10 | 0 | 0 |
| Natural History by Mercantile Marine | 5 | 0 | 0 |
| Tidal Observations | 25 | 0 | 0 |
| Photoheliometer at Kew | 40 | 0 | 0 |
| Photographic Pictures of the Sun | 150 | 0 | 0 |
| Rocks of Donegal | 25 | 0 | 0 |
| Dredging Durham and Northumberland | 25 | 0 | 0 |
| Connexion of Storms | 20 | 0 | 0 |
| Dredging North-East Coast of Scotland | 6 | 9 | 6 |
| Ravages of Teredo | 3 | 11 | 0 |
| Standards of Electrical Resistance | 50 | 0 | 0 |
| Railway Accidents | 10 | 0 | 0 |
| Balloon Committee | 200 | 0 | 0 |
| Dredging Dublin Bay | 10 | 0 | 0 |
| Dredging the Mersey | 5 | 0 | 0 |
| Prison Diet | 20 | 0 | 0 |
| Gauging of Water | 12 | 10 | 0 |
| Steamships' Performance | 150 | 0 | 0 |
| Thermo-Electric Currents | 5 | 0 | 0 |
| | £1293 | 16 | 6 |

| 1863. | £ | s. | d. |
|---|---|---|---|
| Maintaining the Establishment of Kew Observatory | 600 | 0 | 0 |
| Balloon Committee deficiency | 70 | 0 | 0 |
| Balloon Ascents (other expenses) | 25 | 0 | 0 |
| Entozoa | 25 | 0 | 0 |
| Coal Fossils | 20 | 0 | 0 |
| Herrings | 20 | 0 | 0 |
| Granites of Donegal | 5 | 0 | 0 |
| Prison Diet | 20 | 0 | 0 |
| Vertical Atmospheric Movements | 13 | 0 | 0 |
| Dredging Shetland | 50 | 0 | 0 |
| Dredging North-east coast of Scotland | 25 | 0 | 0 |
| Dredging Northumberland and Durham | 17 | 3 | 10 |
| Dredging Committee superintendence | 10 | 0 | 0 |
| Steamship Performance | 100 | 0 | 0 |
| Balloon Committee | 200 | 0 | 0 |
| Carbon under pressure | 10 | 0 | 0 |
| Volcanic Temperature | 100 | 0 | 0 |
| Bromide of Ammonium | 8 | 0 | 0 |
| Electrical Standards | 100 | 0 | 0 |
| —— Construction and distribution | 40 | 0 | 0 |
| Luminous Meteors | 17 | 0 | 0 |
| Kew Additional Buildings for Photoheliograph | 100 | 0 | 0 |
| Thermo-Electricity | 15 | 0 | 0 |
| Analysis of Rocks | 8 | 0 | 0 |
| Hydroids | 10 | 0 | 0 |
| | £1608 | 3 | 10 |

| 1864. | £ | s. | d. |
|---|---|---|---|
| Maintaining the Establishment of Kew Observatory | 600 | 0 | 0 |
| Coal Fossils | 20 | 0 | 0 |
| Vertical Atmospheric Movements | 20 | 0 | 0 |
| Dredging Shetland | 75 | 0 | 0 |
| Dredging Northumberland | 25 | 0 | 0 |
| Balloon Committee | 200 | 0 | 0 |
| Carbon under pressure | 10 | 0 | 0 |
| Standards of Electric Resistance | 100 | 0 | 0 |
| Analysis of Rocks | 10 | 0 | 0 |
| Hydroida | 10 | 0 | 0 |
| Askham's Gift | 50 | 0 | 0 |
| Nitrite of Amyle | 10 | 0 | 0 |
| Nomenclature Committee | 5 | 0 | 0 |
| Rain-Gauges | 19 | 15 | 8 |
| Cast Iron Investigation | 20 | 0 | 0 |
| Tidal Observations in the Humber | 50 | 0 | 0 |
| Spectral Rays | 45 | 0 | 0 |
| Luminous Meteors | 20 | 0 | 0 |
| | £1289 | 15 | 8 |

| 1865. | £ | s. | d. |
|---|---|---|---|
| Maintaining the Establishment of Kew Observatory | 600 | 0 | 0 |
| Balloon Committee | 100 | 0 | 0 |
| Hydroida | 13 | 0 | 0 |
| Rain-Gauges | 30 | 0 | 0 |
| Tidal Observations in the Humber | 6 | 8 | 0 |
| Hexylic Compounds | 20 | 0 | 0 |
| Amyl Compounds | 20 | 0 | 0 |
| Irish Flora | 25 | 0 | 0 |
| American Mollusca | 3 | 9 | 0 |
| Organic Acids | 20 | 0 | 0 |
| Lingula Flags Excavation | 10 | 0 | 0 |
| Eurypterus | 50 | 0 | 0 |
| Electrical Standards | 100 | 0 | 0 |
| Malta Caves Researches | 30 | 0 | 0 |
| Oyster Breeding | 25 | 0 | 0 |
| Gibraltar Caves Researches | 150 | 0 | 0 |
| Kent's Hole Excavations | 100 | 0 | 0 |
| Moon's Surface Observations | 35 | 0 | 0 |
| Marine Fauna | 25 | 0 | 0 |
| Dredging Aberdeenshire | 25 | 0 | 0 |
| Dredging Channel Islands | 50 | 0 | 0 |
| Zoological Nomenclature | 5 | 0 | 0 |
| Resistance of Floating Bodies in Water | 100 | 0 | 0 |
| Bath Waters Analysis | 8 | 10 | 0 |
| Luminous Meteors | 40 | 0 | 0 |
| | £1591 | 7 | 10 |

| 1866. | £ | s. | d. |
|---|---|---|---|
| Maintaining the Establishment of Kew Observatory | 600 | 0 | 0 |
| Lunar Committee | 64 | 13 | 4 |
| Balloon Committee | 50 | 0 | 0 |
| Metrical Committee | 50 | 0 | 0 |
| British Rainfall | 50 | 0 | 0 |
| Kilkenny Coal Fields | 16 | 0 | 0 |
| Alum Bay Fossil Leaf-Bed | 15 | 0 | 0 |
| Luminous Meteors | 50 | 0 | 0 |
| Lingula Flags Excavation | 20 | 0 | 0 |
| Chemical Constitution of Cast Iron | 50 | 0 | 0 |
| Amyl Compounds | 25 | 0 | 0 |
| Electrical Standards | 100 | 0 | 0 |
| Malta Caves Exploration | 30 | 0 | 0 |
| Kent's Hole Exploration | 200 | 0 | 0 |
| Marine Fauna, &c., Devon and Cornwall | 25 | 0 | 0 |
| Dredging Aberdeenshire Coast | 25 | 0 | 0 |
| Dredging Hebrides Coast | 50 | 0 | 0 |
| Dredging the Mersey | 5 | 0 | 0 |
| Resistance of Floating Bodies in Water | 50 | 0 | 0 |
| Polycyanides of Organic Radicals | 20 | 0 | 0 |
| Rigor Mortis | 10 | 0 | 0 |
| Irish Annelida | 15 | 0 | 0 |
| Catalogue of Crania | 50 | 0 | 0 |
| Didine Birds of Mascarene Islands | 50 | 0 | 0 |
| Typical Crania Researches | 30 | 0 | 0 |
| Palestine Exploration Fund | 100 | 0 | 0 |
| | £1750 | 13 | 4 |

## *Extracts from Resolutions of the General Committee.*

Committees and individuals, to whom grants of money for scientific purposes have been entrusted, are required to present to each following meeting of the Association a Report of the progress which has been made; with a statement of the sums which have been expended, and the balance which remains disposable on each grant.

Grants of pecuniary aid for scientific purposes from the funds of the Association expire at the ensuing meeting, unless it shall appear by a Report that the Recommendations have been acted on, or a continuation of them be ordered by the General Committee.

In each Committee, the Member first named is the person entitled to call on the Treasurer, William Spottiswoode, Esq., 50 Grosvenor Place, London, S.W., for such portion of the sum granted as may from time to time be required.

In grants of money to Committees, the Association does not contemplate the payment of personal expenses to the members.

In all cases where additional grants of money are made for the continuation of Researches at the cost of the Association, the sum named shall be deemed to include, as a part of the amount, the specified balance which may remain unpaid on the former grant for the same object.

### *General Meetings.*

On Wednesday Evening, August 22, at 8 P.M., in the Theatre, Professor John Phillips, M.A., LL.D., F.R.S., F.G.S., resigned the office of President to William R. Grove, Esq., M.A., F.R.S., who took the Chair, and delivered an Address, for which see page liii.

On Thursday Evening, August 23, at 8 P.M., a Soirée took place in the Exhibition Building.

On Friday Evening, August 24, at 8.30 P.M., in the Theatre, William Huggins, Esq., delivered a Discourse on the "Results of Spectrum Analysis as Applied to the Heavenly Bodies."

On Monday Evening, August 27, at 8.30 P.M., in the Theatre, Joseph Hooker, Esq., M.D., F.R.S., delivered a Discourse on "Insular Floras."

On Tuesday Evening, August 28, at 8 P.M., a Soirée took place in the Exhibition Building.

On Wednesday, August 29, at 3 P.M., the concluding General Meeting took place, when the Proceedings of the General Committee, and the Grants of Money for Scientific purposes, were explained to the Members.

The Meeting was then adjourned to Dundee*.

* The Meeting is appointed to take place on Wednesday, September 4, 1867.

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CALIFORNIA

# ADDRESS

OF

## WILLIAM ROBERT GROVE, Esq., Q.C., M.A., F.R.S.,

PRESIDENT.

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If our rude predecessors, who at one time inhabited the caverns which surround this town, could rise from their graves and see it in its present state, it may be doubtful whether they would have sufficient knowledge to be surprised.

The machinery, almost resembling organic beings in delicacy of structure, by which are fabricated products of world-wide reputation, the powers of matter applied to give motion to that machinery, are so far removed from what must have been the conceptions of the semibarbarians to whom I have alluded, that they could not look on them with intelligent wonder.

Yet this immense progress has all been effected step by step, now and then a little more rapidly than at other times; but, viewing the whole course of improvement, it has been gradual, though moving in an accelerated ratio. But it is not merely in those branches of natural knowledge which tend to improvements in economical arts and manufactures, that science has made great progress. In the study of our own planet and the organic beings with which it is crowded, and in so much of the universe, as vision, aided by the telescope, has brought within the scope of observation, the present century has surpassed any antecedent period of equal duration.

It would be difficult to trace out all the causes which have led to the increase of observational and experimental knowledge.

Among the more thinking portion of mankind the gratification felt by the discovery of new truths, the expansion of faculties, and extension of the boundaries of knowledge have been doubtless a sufficient inducement to the study of nature; while, to the more practical minds, the reality, the certainty, and the progressive character of the acquisitions of natural science, and the enormously increased means which its applications give, have impressed its importance as a minister to daily wants and a contributor to ever-increasing material comforts, luxury, and power.

Though by no means the only one, yet an important cause of the rapid advance of science is the growth of associations for promoting the progress either of physical knowledge generally, or of special branches of it. Since the foundation of the Royal Society, now more than two centuries ago, a vast number of kindred societies have sprung up in this country and in Europe. The advantages conferred by these societies are manifold; they enable those who are devoted to scientific research, to combine, compare, and

check their observations, to assist, by the thoughts of several minds, the promotion of the inquiry undertaken; they contribute from a joint purse to such efforts as their members deem most worthy; they afford a means of submitting to a competent tribunal notices and memoirs, and of obtaining for their authors and others, by means of the discussions which ensue, information given by those best informed on the particular subject; they enable the author to judge whether it is worth his while to pursue the subjects he has brought forward, and they defray the expense of printing and publishing such researches as are thought deserving of it.

These advantages, and others might be named, pertain to the Association the 36th Meeting of which we are this evening assembled to inaugurate; but it has, from its intermittent and peripatetic character, advantages which belong to none of the societies which are fixed as to their locality.

Among these are the novelty and freshness of an annual meeting, which, while it brings together old Members of the Association, many of whom only meet on this occasion, always adds a quota of new Members, infusing new blood, and varying the social character of our meetings.

The visits of distinguished foreigners, whom we have previously known by reputation, is one of the most delightful and improving of the results. The wide field of inquiry, and the character of communications made to the Association, including all branches of natural knowledge, and varying from simple notices of an interesting observation or experiment, to the most intricate and refined branches of scientific research, is another valuable characteristic.

Lastly, perhaps the greatest advantage resulting from the annual visits of this great parliament to new localities is that, while it imparts fresh local knowledge to the visitors, it leaves behind stimulating memories, which rouse into permanent activity dormant or timid minds—an effect which, so far from ceasing with the visit of the Association, frequently begins when that visit terminates.

Every votary of physical science must be anxious to see it recognized by those institutions of the country which can to the greatest degree promote its cultivation and reap from it the greatest benefit. You will probably agree with me that the principal educational establishments on the one hand, and on the other the Government, in many of its departments, are the institutions which may best fulfil these conditions. The more early the mind is trained to a pursuit of any kind, the deeper and more permanent are the impressions received, and the more service can be rendered by the students.

> "Quo semel est imbuta recens servabit odorem
> Testa diu."

Little can be achieved in scientific research without an acquaintance with it in youth; you will rarely find an instance of a man who has attained any eminence in science who has not commenced its study at a very early period of life. Nothing, again, can tend more to the promotion of science than the exertions of those who have early acquired the ἦθος resulting from a scientific education. I desire to make no complaint of the tardiness with which science has been received at our public schools and, with some exceptions, at our Universities. These great establishments have their roots in historical periods, and long time and patient endeavour is requisite before a new branch of thought can be grafted with success on a stem to which it is exotic. Nor should I ever wish to see the study of languages, of history, of all those refined associations which the past has transmitted to us, ne-

glected; but there is room for both. It is sad to see the number of so-called educated men who, travelling by railway, voyaging by steamboat, consulting the almanac for the time of sunrise or full-moon, have not the most elementary knowledge of a steam-engine, a barometer, or a quadrant; and who will listen with a half-confessed faith to the most idle predictions as to weather or cometic influences, while they are in a state of crass ignorance as to the cause of the trade-winds or the form of a comet's path. May we hope that the slight infiltration of scientific studies, now happily commenced, will extend till it occupies its fair space in the education of the young, and that those who may be able learnedly to discourse on the Eolic digamma will not be ashamed of knowing the principles on which the action of an air-pump, an electrical machine, or a telescope depends, and will not, as Bacon complained of his contemporaries, despise such knowledge as something mean and mechanical.

To assert that the great departments of Government should encourage physical science may appear a truism, and yet it is but of late that it has been seriously done; now, the habit of consulting men of science on important questions of national interest is becoming a recognized practice, and in a time, which may seem long to individuals, but is short in the history of a nation, a more definite sphere of usefulness for national purposes will, I have no doubt, be provided for those duly qualified men who may be content to give up the more tempting study of abstract science for that of its practical applications. In this respect the Report of the Kew Committee for this year affords a subject of congratulation to those whom I have the honour to address. The Kew Observatory, the petted child of the British Association, may possibly become an important national establishment; and if so, while it will not, I trust, lose its character of a home for untrammelled physical research, it will have superadded some of the functions of the Meteorological Department of the Board of Trade with a staff of skilful and experienced observers.

This is one of the results which the general growth of science, and the labours of this Association in particular, have produced; but I do not propose on this occasion to recapitulate the special objects attained by the Association, this has been amply done by several of my predecessors; nor shall I confine my address to the progress made in physical science since the time when my most able and esteemed friend and predecessor addressed you at Birmingham. In the various reports and communications which will be read at your Sections, details of every step which has been made in science since our last Meeting will be brought to your notice, and I have no doubt fully and freely discussed.

I purpose, with your kind permission, to submit to you certain views of what has within a comparatively recent period been accomplished by science, what have been the steps leading to the attained results, and what, as far as we may fairly form an opinion, is the general character pervading modern discovery.

It seems to me that the object we have in view would be more nearly approached, by each President, chosen as they are in succession as representing different branches of science, giving on these occasions either an account of the progress of the particular branch of science he has cultivated, when that is not of a very limited and special character, or enouncing his own view of the general progress of science; and though this will necessarily involve much that belongs to recent years, the confining a President to a mere *résumé* of what has taken place since our last Meeting would, I

venture with diffidence to think, limit his means of usefulness, and render his discourse rather an annual register than an instructive essay.

I need not dwell on the common-place but yet important topics of the material advantages resulting from the application of science; I will address myself to what, in my humble judgment, are the lessons we have learned and the probable prospects of improved natural knowledge.

One word will give you the key to what I am about to discourse on; that word is *continuity*, no new word, and used in no new sense, but perhaps applied more generally than it has hitherto been. We shall see, unless I am much mistaken, that the development of observational, experimental, and even deductive knowledge is either attained by steps so extremely small as to form really a continuous ascent; or, when distinct results apparently separate from any coordinate phenomena have been attained, that then, by the subsequent progress of science, intermediate links have been discovered uniting the apparently segregated instances with other more familiar phenomena.

Thus the more we investigate, the more we find that in existing phenomena graduation from the like to the seemingly unlike prevails, and in the changes which take place in time, gradual progress is, and apparently must be, the course of nature.

Let me now endeavour to apply this view to the recent progress of some of the more prominent branches of science.

In Astronomy, from the time when the earth was considered a flat plain bounded by a flat ocean,—when the sun, moon, and stars were regarded as lanterns to illuminate this plain,—each successive discovery has brought with it similitudes and analogies between this earth and many of the objects of the universe with which our senses, aided by instruments, have made us acquainted. I pass, of course, over those discoveries which have established the Copernican system as applied to our sun, its attendant planets, and their satellites. The proofs, however, that gravitation is not confined to our solar system, but pervades the universe, have received many confirmations by the labours of Members of this Association; I may name those who have held the office of President, Lord Rosse, Lord Wrottesley, and Sir J. Herschel, the latter having devoted special attention to the orbits of double stars, the former to those probably more recent systems called nebulæ. Double stars seem to be orbs analogous to our own sun and revolving round their common centre of gravity in a conic-section curve, as do the planets with which we are more intimately acquainted; but the nebulæ present more difficulty, and some doubt has been expressed whether gravitation, such as we consider it, acts with those bodies (at least those exhibiting a spiral form) as it does with us; possibly some other modifying influence may exist, our present ignorance of which gives rise to the apparent difficulty. There is, however, another class of observations quite recent in its importance, and which has formed a special subject of contribution to the Reports and Transactions of this Association; I allude to those on Meteorites, at which our lamented Member, and to many of us our valued friend, Prof. Baden Powell assiduously laboured, for investigations into which a Committee of this Association is formed, and a series of star-charts for enabling observers of shooting-stars to record their observations was laid before the last Meeting of the Association by Mr. Glaisher.

It would occupy too much of your time to detail the efforts of Bessel, Schwinke, the late Sir J. Lubbock, and others, as applied to the formation of star-charts for aiding the observation of meteorites which Mr. Alexander Herschel, Mr. Brayley, Mr. Sorby, and others are now studying.

Dr. Olmsted explained the appearance of a point from which the lines of flight of meteors seem to radiate, as being the perspective vanishing point of their parallel or nearly parallel courses appearing to an observer on the earth as it approaches them. The uniformity of position of these radiant points, the many corroborative observations on the direction, the distances, and the velocities of these bodies, the circumstance that their paths intersect the earth's orbit at certain definite periods, and the total failure of all other theories which have been advanced, while there is no substantial objection to this, afford evidence almost amounting to proof that these are cosmical bodies moving in the interplanetary space by gravitation round the sun, and some perhaps round planets. This view gives us a new element of continuity. The universe would thus appear not to have the extent of empty space formerly attributed to it, but to be studded between the larger and more visible masses with smaller planets, if the term be permitted to be applied to meteorites.

Observations are now made at the periods at which meteors appear in greatest numbers—at Greenwich by Mr. Glaisher, at Cambridge by Prof. Adams, and at Hawkhurst by Mr. Alexander Herschel—and every preparation is made to secure as much accuracy as can, in the present state of knowledge, be secured for such observations.

The number of known asteroids, or bodies of a smaller size than what are termed the ancient planets, has been so increased by numerous discoveries, that instead of seven we now count eighty-eight as the number of recognized planets—a field of discovery with which the name of Hind will be ever associated.

If we add these, the smallest of which is only twenty or thirty miles in diameter, indeed cannot be accurately measured, and if we were to apply the same scrutiny to other parts of the heavens as has been applied to the zone between Mars and Jupiter, it is no far-fetched speculation to suppose that in addition to asteroids and meteorites, many other bodies exist until the space occupied by our solar system becomes filled up with planetary bodies varying in size from that of Jupiter (1240 times larger in volume than the earth) to that of a cannon-ball or even a pistol-bullet.

The researches of Leverrier on the intra-mercurial planets come in aid of these views; and another half century may, and not improbably will, enable us to ascertain that the now seemingly vacant interplanetary spaces are occupied by smaller bodies which have hitherto escaped observation, just as the asteroids had until the time of Olbers and Piazzi. But the evidence of continuity as pervading the universe does not stop at telescopic observation; chemistry and physical optics bring us new proofs. Those meteoric bodies which have from time to time come so far within reach of the earth's attraction as to fall upon its surface, give on analysis metals and oxides similar to those which belong to the structure of the earth—they come as travellers bringing specimens of minerals from extra-terrestrial regions.

In a series of papers recently communicated to the French Academy, M. Daubrée has discussed the chemical and mineralogical character of meteorites as compared with the rocks of the earth. He finds that the similarity of terrestrial rocks to meteorites increases as we penetrate deeper into the earth's crust, and that some of the deep-seated minerals have a composition and characteristics almost identical with meteorites [olivine, herzolite, and serpentine, for instance, closely resemble them]; that as we approach the surface, rocks having similar components with meteorites are found, but in a state of oxidation, which necessarily much modifies their

mineral character, and which, by involving secondary oxygenized compounds, must also change their chemical constitution. By experiments he has succeeded in forming from terrestrial rocks substances very much resembling meteorites. Thus close relationship, though by no means identity, is established between this earth and those wanderers from remote regions, some evidence, though at present incomplete, of a common origin.

Surprise has often been expressed that, while the mean specific gravity of this globe is from five to six times that of water, the mean specific gravity of its crust is barely half as great. It has long seemed to me that there is no ground for wonder here. The exterior of our planet is to a considerable depth oxidated; the interior is in all probability free from oxygen, and whatever bodies exist there are in a reduced or deoxidated state, if so, their specific gravity must necessarily be higher than that of their oxides or chlorides, &c.: we find, moreover, that some of the deep seated minerals have a higher specific gravity than the average of those on the surface; olivine, for instance, has a specific gravity of 3·3. There is therefore no *à priori* improbability that the mean specific gravity of the earth should notably exceed that of its surface; and if we go further and suppose the interior of the earth to be formed of the same ingredients as the exterior, minus oxygen, chlorine, bromine, &c., a specific gravity of 5 to 6 would not be an unlikely one. Many of the elementary bodies entering largely into the formation of the earth's crust are as light or lighter than water,—for instance, potassium, sodium, &c.; others, such as sulphur, silicon, aluminium, have from two to three times its specific gravity; others, again, as iron, copper, zinc, tin, seven to nine times; while others, lead, gold, platinum, &c., are much more dense,—but, speaking generally, the more dense are the least numerous. There seems no improbability in a mixture of such substances producing a mean specific gravity of from 5 to 6, although it by no means follows, indeed the probability is rather the other way, that the proportions of the substances in the interior of the earth are the same as on the exterior. It might be worth the labour to ascertain the mean specific gravity of all the known minerals on the earth's surface, averaging them in the ratios in which, as far as our knowledge goes, they quantitatively exist, and assuming them to exist without the oxygen, chlorine, &c., with which they are, with some rare exceptions, invariably combined on the surface of the earth: great assistance to the knowledge of the probable constitution of the earth might be derived from such an investigation.

While chemistry, analytic and synthetic, thus aids us in ascertaining the relationship of our planet to meteorites, its relation in composition to other planets, to the sun, and to more distant suns and systems is aided by another science, viz. optics.

That light passing from one transparent medium to another should carry with it evidence of the source from which it emanates, would, until lately, have seemed an extravagant supposition; but probably (could we read it) everything contains in itself a large portion of its own history.

I need not detail to you the discoveries of Kirchhoff, Bunsen, Miller, Huggins, and others, they have been dilated on by my predecessor. Assuming that spectrum analysis is a reliable indication of the presence of given substances by the position of transverse bright lines exhibited when they are burnt and of transverse dark lines when light is transmitted through their vapours, though Plücker has shown that with some substances these lines vary with temperature, the point of importance in the view I am presenting to you is, that while what may be called comparatively neighbouring cosmical bodies

exhibit lines identical with many of those shown by the components of this planet, as we proceed to the more distant appearances of the nebulæ we get but one or two of such lines, and we get one or two new bands not yet identified with any known to be produced by substances on this globe.

Within the last year Mr. Huggins has added to his former researches observations on the spectrum of a comet (comet 1 of 1866), the nucleus of which shows but one bright line, while the spectrum formed by the light of the coma is continuous, seeming to show that the nucleus is gaseous while the coma would consist of matter in a state of minute division shining by reflected light: whether this be solid, liquid, or gaseous is doubtful; but the author thinks it is in a condition analogous to that of fog or cloud. The position in the spectrum of the bright line furnished by the nucleus is the same as that of nitrogen, which also is shown in some of the nebulæ.

But the most remarkable achievement by spectrum analysis is the record of observations on a temporary star which has shone forth this year in the constellation of the northern crown about a degree S.E. of the star *ε*. When it was first seen, May 12th, it was nearly equal in brilliancy to a star of the second magnitude; when observed by Mr. Huggins and Dr. Miller, May 16th, it was reduced to the third or fourth magnitude. Examined by these observers with the spectroscope, it gave a spectrum which they state was unlike that of any celestial body they had examined.

The light was compound and had emanated from two different sources. One spectrum was analogous to that of the sun, viz., formed by the light of an incandescent solid or liquid photosphere which had suffered absorption by the vapours of an envelope cooler than itself. The second spectrum consisted of a few bright lines, which indicated that the light by which it was formed was emitted by matter in the state of luminous gas. They consider that, from the position of two of the bright lines, the gas must be probably hydrogen, and from their brilliancy compared with the light of the photosphere the gas must have been at a very high temperature. They imagine the phenomena to result from the burning of hydrogen with some other element, and that from the resulting temperature the photosphere is heated to incandescence.

There is strong reason to believe that this star is one previously seen by Argelander and Sir J. Herschel, and that it is a variable star of long or irregular period; it is also notable that some of its spectrum lines correspond with those of several variable stars. The time of its appearance was too short for any attempt to ascertain its parallax; it would have been important if it could even have been established that it is not a near neighbour, as the magnitude of such a phenomenon must depend upon its distance. I forbear to add any speculations as to the cause of this most singular phenomenon; however imperfect the knowledge given us by these observations, it is a great triumph to have caught this fleeting object, and obtained permanent records for the use of future observers.

It would seem as if the phenomenon of gradual change obtained towards the remotest objects with which we are at present acquainted, and that the further we penetrate into space the more unlike to those we are acquainted with become the objects of our examination,—sun, planets, meteorites, earth similarly though not identically constituted, stars differing from each other and from our system, and nebulæ more remote in space and differing more in their characters and constitution.

While we thus can to some extent investigate the physical constitution of the most remote visible substances, may we not hope that some further insight as to the constitution of the nearest, viz. our own satellite, may be given us

by this class of researches? The question whether the moon possesses any atmosphere may still be regarded as unsolved. If there be any, it must be exceedingly small in quantity and highly attenuated. Calculations, made from occultation of stars, on the apparent differences of the semidiameter of the bright and dark moon give an amount of difference which might indicate a minute atmosphere, but which Mr. Airy attributes to irradiation.

Supposing the moon to be constituted of similar materials to the earth, it must be, to say the least, doubtful whether there is oxygen enough to oxidate the metals of which she is composed; and if not, the surface which we see must be metallic, or nearly so. The appearance of her craters is not unlike that seen on the surface of some metals, such as bismuth, or, according to Professor Phillips, silver, when cooling from fusion and just previous to solidifying; and it might be a fair subject of inquiry whether, if there be any coating of oxide on the surface, it may not be so thin as not to disguise the form of the congealed metallic masses, as they may have set in cooling from igneous fusion. M. Chacornac's recent observations lead him to suppose that many of the lunar craters were the result of a single explosion, which raised the surface as a bubble and deposited its débris around the orifice of eruption.

The eruptions on the surface of the moon clearly did not take place at one period only, for at many parts of the disk craters may be seen encroaching on and disfiguring more ancient craters, sometimes to the extent of three or four successive displacements: two important questions might, it seems to me, be solved by an attentive examination of such portions of the moon. By observing carefully with the most powerful telescopes the character of the ridges thus successively formed, the successive states of the lunar surface at different epochs might be elucidated; and secondly, as on the earth we should look for actual volcanic action at those points where recent eruptions have taken place, so on the moon the more recently active points being ascertained by the successive displacement of anterior formations, it is these points which should be examined for existing disruptive disturbances. Metius and Fabricius might be cited as points of this character, having been found by M. Chacornac to present successive displacements and to be perforated by numerous channels or cavities. M. Chacornac considers that the seas, as they are called, or smoother portions of the lunar surface have at some time made inroads on anteriorly formed craters; if so, a large portion of the surface of the moon must have been in a fused, liquid, semiliquid, or alluvial state long after the solidifying of other portions of it. It would be difficult to suppose that this state was one of igneous fusion, for this could hardly exist over a large part of the surface without melting up the remaining parts; on the other hand, the total absence of any signs of water, and of any, or, if any, only the most attenuated, atmosphere, would make it equally difficult to account for a large diluvial formation.

Some substances, like mercury on this planet, might have remained liquid after others had solidified; but the problem is one which needs more examination and study before any positive opinion can be pronounced.

I cannot pass from the subject of lunar physics without recording the obligation we are under to our late President for his most valuable observations and for his exertion in organizing a band of observers devoted to the examination of this our nearest celestial neighbour, and to Mr. Nasmyth and Mr. De la Rue for their important graphical and photographical contributions to this subject. The granular character of the sun's surface observed by Mr. Nasmyth in 1860 is also a discovery which ought not to be passed over in

Before quitting the subject of Astronomy I cannot avoid expressing a feeling of disappointment that the achromatic telescope, which has rendered such notable service to this science, still retains in practice the great defect which was known a century ago at the time of Hall and Dollond, namely, the inaccuracy of definition arising from what was termed the irrationality of the spectrum, or the incommensurate divisions of the spectra formed by flint and crown glass.

The beautiful results obtained by Blair have remained inoperative from the circumstance that evaporable liquids being employed between the lenses, a want of permanent uniformity in the instrument was experienced; and notwithstanding the high degree of perfection to which the grinding and polishing object-glasses has been brought by Clarke, Cooke, and Mertz, notwithstanding the greatly improved instrumental manufacture, the defect to which I have adverted remains unremedied and an eyesore to the observer with the refracting telescope.

We have now a large variety of different kinds of glass formed from different metallic oxides. A list of many such was given by M. Jacquelain a few years back; the last specimen which I have seen is a heavy highly refracting glass formed from the metal thallium by M. Lamy. Among all these could no two or three be selected which, having appropriate refracting and dispersing powers, would have the coloured spaces of their respective spectra if not absolutely in the same proportions, at all events much more nearly so than those of flint and crown glass? Could not, again, oily or resinous substances, such as castor oil, canada balsam, &c, having much action on the more refrangible rays of the spectrum, be made use of in combination with glass lenses to reduce if not annihilate this signal defect? This is not a problem to the solution of which there seems any insuperable difficulty; the reason why it has not been solved is, I incline to think, that the great practical opticians have no time at their disposal to devote to long tentative experiments and calculations, and on the other hand the theoretic opticians have not the machinery and the skill in manipulation requisite to give the appropriate degree of excellence to the materials with which they experiment; yet the result is worth labouring for, as, could the defect be remedied, the refracting telescope would make nearly as great an advance upon its present state as the achromatic did on the single lens refractor.

While gravitation, physical constitution, and chemical analysis by the spectrum show us that matter has similar characteristics in other worlds than our own, when we pass to the consideration of those other attributes of matter which were at one time supposed to be peculiar kinds of matter itself, or, as they were called, imponderables, but which are now generally, if not universally, recognized as forces or modes of motion, we find the evidence of continuity still stronger.

When all that was known of magnetism was that a piece of steel rubbed against a particular mineral had the power of attracting iron, and, if freely suspended, of arranging itself nearly in a line with the earth's meridian, it seemed an exceptional phenomenon. When it was observed that amber, if rubbed, had the temporary power of attracting light bodies, this also seemed something peculiar and anomalous. What are now magnetism and electricity? forces so universal, so apparently connected with matter as to become two of its invariable attributes, and that to speak of matter not being capable of being affected by these forces would seem almost as extravagant as to speak of matter not being affected by gravitation.

So with light, heat, and chemical affinity, not merely is every form of

matter with which we are acquainted capable of manifesting all these modes of force, but so-called matter supposed incapable of such manifestations would to most minds cease to be matter.

Further than this it seems to me (though, as I have taken an active part for many years, now dating from a quarter of a century, in promoting this view, I may not be considered an impartial judge) that it is now proved that all these forces are so invariably connected *inter se* and with motion as to be regarded as modifications of each other, and as resolving themselves objectively into motion, and subjectively into that something which produces or resists motion, and which we call force.

I may perhaps be permitted to recal a forgotten experiment, which nearly a quarter of a century ago I showed at the London Institution, an experiment simple enough in itself, but which then seemed to me important from the consequences to be deduced from it, and the importance of which will be much better appreciated now than then.

A train of multiplying wheels ended with a small metallic wheel which, when the train was put in motion, revolved with extreme rapidity against the periphery of the next wheel, a wooden one. In the metallic wheel was placed a small piece of phosphorus, and as long as the wheels revolved, the phosphorus remained unchanged, but the moment the last wheel was stopped by moving a small lever attached to it, the phosphorus burst into flame. My object was to show that while motion of the mass continued, heat was not generated, but that when this was arrested, the force continuing to operate, the motion of the mass became heat in the particles. The experiment differed from that of Rumford's cannon-boring and Davy's friction of ice in showing that there was no heat while the motion was unresisted, but that the heat was in some way dependent on the motion being impeded or arrested. We have now become so accustomed to this view, that whenever we find motion resisted we look to heat, electricity, or some other force as the necessary and inevitable result.

It would be out of place here, and treating of matters too familiar to the bulk of my audience, to trace how, by the labours of Oersted, Seebeck, Faraday, Talbot, Daguerre, and others, materials have been provided for the generalization now known as the correlation of forces or conservation of energy, while Davy, Rumford, Seguin, Mayer, Joule, Helmholtz, Thomson, and others (among whom I would not name myself, were it not that I may be misunderstood and supposed to have abandoned all claim to a share in the initiation of this, as I believe, important generalization) have carried on the work; and how, sometimes by independent and, as is commonly the case, nearly simultaneous deductions, sometimes by progressive and accumulated discoveries, the doctrine of the reciprocal interaction, of the quantitative relation, and of the necessary dependence of all the forces has, I think I may venture to say, been established.

If magnetism, be, as it is proved to be, connected with the other forces or affections of matter, if electrical currents always produce, as they are proved to do, lines of magnetic force at right angles to their lines of action, magnetism must be cosmical, for where there is heat and light, there is electricity and consequently magnetism. Magnetism, then, must be cosmical and not merely terrestrial. Could we trace magnetism in other planets and suns as a force manifested in axial or meridional lines, *i. e.* in lines cutting at right angles the curves formed by their rotation round an axis, it would be a great step; but it is one hitherto unaccomplished. The apparent coincidences between the maxima and minima of solar spots, and the decennial or undecen-

nial periods of terrestrial magnetic intensity, though only empirical at present, might tend to lead us to a knowledge of the connexion we are seeking; and the President of the Royal Society considers that an additional epoch of coincidence has arrived, making the fourth decennial period; but some doubt is thrown upon these coincidences by the magnetic observations made at Greenwich Observatory. In a paper published in the 'Transactions of the Royal Society,' 1863, the Astronomer Royal says, speaking of results extending over seventeen years, there is no appearance of decennial cycle in the recurrence of great magnetic disturbances; and Mr. Glaisher last year, in the physical section of this Association, stated that after persevering examination he had been unable to trace any connexion between the magnetism of the earth and the spots on the sun.

Mr. Airy, however, in a more recent paper, suggests that currents of magnetic force having reference to the solar hour are detected, and seem to produce vortices or circular disturbances, and he invites further cooperative observation on the subject, one of the highest interest, but at present remaining in great obscurity.

One of the most startling suggestions as to the consequence resulting from the dynamical theory of heat is that made by Mayer, that by the loss of *vis viva* occasioned by friction of the tidal waves, as well as by their forming, as it were, a drag upon the earth's rotatory movement, the velocity of the earth's rotation must be gradually diminishing, and that thus, unless some undiscovered compensatory action exist, this rotation must ultimately cease, and changes hardly calculable take place in the solar system.

M. Delaunay considers that part of the acceleration of the moon's mean motion which is not at present accounted for by planetary disturbances, to be due to the gradual retardation of the earth's rotation; to which view, after an elaborate investigation, the Astronomer Royal has given his assent.

Another most interesting speculation of Mayer is that with which you are familiar, viz., that the heat of the sun is occasioned by friction or percussion of meteorites falling upon it: there are some difficulties, not perhaps insuperable, in this theory. Supposing such cosmical bodies to exist in sufficient numbers they would, as they revolve round the sun, fall into it, not as an aërolite falls upon the earth directly by an intersection of orbits, but by the gradual reduction in size of the orbits, occasioned by a resisting medium; some portion of force would be lost, and heat generated in space by friction against such medium; when they arrive at the sun they would, assuming them, like the planets, to have revolved in the same direction, all impinge in a definite direction, and we might expect to see some symptoms of such in the sun's photosphere; but though this is in a constant state of motion, and the direction of these movements has been carefully investigated by Mr. Carrington and others, no such general direction is detected; and M. Faye, who some time ago wrote a paper pointing out many objections to the theory of solar heat being produced by the fall of meteoric bodies into the sun, has recently investigated the proper motions of sun-spots, and believes he has removed certain apparent anomalies and reduced their motions to a certain regularity in the motion of the photosphere, attributable to some general action arising from the internal mass of the sun.

It might be expected that comets, bodies so light and so easily deflected from their course, would show some symptoms of being acted on by gravitation, were such a number of bodies to exist in or near their paths, as are presupposed in the mechanical theory of solar heat.

Assuming the undulatory theory of light to be true, and that the motion

which constitutes light is transmitted across the interplanetary spaces by a highly elastic ether, then, unless this motion is confined to one direction, unless there be no interference, unless there be no viscosity, as it is now termed, in the medium, and consequently no friction, light must lose something in its progress from distant luminous bodies, that is to say, must lose something as light; for, as all reflecting minds are now convinced that force cannot be annihilated, the force is not lost, but its mode of action is changed. If light, then, is lost as light (and the observations of Struvé seem to show this to be so, that, in fact, a star may be so far distant that it can never be seen in consequence of its luminous emissions becoming extinct), what becomes of the transmitted force lost as light, but existing in some other form? So with heat: our sun, our earth, and planets are constantly radiating heat into space, so in all probability are the other suns, the stars, and their attendant planets. What becomes of the heat thus radiated into space? If the universe have no limit, and it is difficult to conceive one, heat and light should be everywhere uniform; and yet more is given off than is received by each cosmical body, for otherwise night would be as light and as warm as day. What becomes of the enormous force thus apparently non-recurrent in the same form? Does it return as palpable motion? Does it move or contribute to move suns and planets? and can it be conceived as a force similar to that which Newton speculated on as universally repulsive and capable of being substituted for universal attraction? We are in no position at present to answer such questions as these; but I know of no problem in celestial dynamics more deeply interesting than this, and we may be no further removed from its solution than the predecessors of Newton were from the simple dynamical relation of matter to matter which that potent intellect detected and demonstrated.

Passing from extraterrestrial theories to the narrower field of molecular physics, we find the doctrine of correlation of forces steadily making its way. In the Bakerian Lecture for 1863 Mr. Sorby shows, not perhaps a direct correlation of mechanical and chemical forces, but that when, either by solution or by chemical action, a change in volume of the resulting substance as compared with that of its separate constituents is effected, the action of pressure retards or promotes the change, according as the substance formed would occupy a larger or a smaller space than that occupied by its separate constituents; the application of these experiments to geological inquiries as to subterranean changes which may have taken place under great pressure is obvious, and we may expect to form compounds under artificial compression which cannot be found under normal pressure.

In a practical point of view the power of converting one mode of force into another is of the highest importance, and with reference to a subject which at present, somewhat prematurely perhaps, occupies men's minds, viz. the prospective exhaustion of our coal-fields, there is every encouragement derivable from the knowledge that we can at will produce heat by the expenditure of other forces; but, more than that, we may probably be enabled to absorb or store up as it were diffused energy—for instance, Berthelot has found that the potential energy of formate of potash is much greater than that of its proximate constituents, caustic potash and carbonic oxide. This change may take place spontaneously and at ordinary temperatures, and by such change carbonic oxide becomes, so to speak, reinvested with the amount of potential energy which its carbon possessed before uniting with oxygen, or, in other words, the carbonic oxide is raised as a force-possessor to the place of carbon by the direct absorption or conversion of heat from surrounding matter.

Here we have, as to force-absorption, an analogous result to that of the formation of coal from carbonic acid and water; and though this is a mere illustration, and may never become economical on a large scale, still it and similar examples may calm apprehension as to future means of supplying heat, should our present fuel become exhausted. As the sun's force, spent in times long past, is now returned to us from the coal which was formed by that light and heat, so the sun's rays, which are daily wasted, as far as we are concerned, on the sandy deserts of Africa, may hereafter, by chemical or mechanical means, be made to light and warm the habitations of the denizens of colder regions. The tidal wave is, again, a large reservoir of force hitherto almost unused.

The valuable researches of Prof. Tyndall on radiant heat afford many instances of the power of localizing, if the term be permitted, heat which would otherwise be dissipated.

The discoveries of Graham, by which atmospheric air, drawn through films of caoutchouc, leaves behind half its nitrogen, or, in other words, becomes richer by half in oxygen, and hence has a much increased potential energy, not only show a most remarkable instance of physical molecular action, merging into chemical, but afford us indications of means of storing up force, much of the force used in working the aspirator being capable at any period, however remote, of being evolved by burning the oxygen with a combustible.

What changes may take place in our modes of applying force before the coal-fields are exhausted it is impossible to predict. Even guesses at the probable period of their exhaustion are uncertain. There is a tendency to substitute for smelting in metallurgic processes, liquid chemical action, which of course has the effect of saving fuel; and the waste of fuel in ordinary operations is enormous, and can be much economized by already known processes. It is true that we are, at present, far from seeing a practical mode of replacing that granary of force the coal-fields; but we may with confidence rely on invention being in this case, as in others, born of necessity, when the necessity arises.

I will not further pursue this subject; at a time when science and civilization cannot prevent large tracts of country being irrigated by human blood in order to gratify the ambition of a few restless men, it seems an over-refined sensibility to occupy ourselves with providing means for our descendants in the tenth generation to warm their dwellings or propel their locomotives.

Two very remarkable applications of the convertibility of force have been recently attained by the experiments of Mr. Wilde and Mr. Holz; the former finds that, by conveying electricity from the coils of a magneto-electric machine to an electro-magnet, a considerable increase of electrical power may be attained, and by applying this as a magneto-electric machine to a second, and this in turn to a third electro-magnetic apparatus, the force is largely augmented. Of course, to produce this increase, more mechanical force must be used at each step to work the magneto-electric machines; but provided this be supplied there hardly seems a limit to the extent to which mechanical may be converted into electrical force.

Mr. Holz has contrived a Franklinic electrical machine, in which a similar principle is manifested. A varnished glass plate is made to revolve in close proximity to another plate having two or more pieces of card attached, which are electrified by a bit of rubbed glass or ebonite; the moment this is effected a resistance is felt by the operator who turns the handle of the machine, and

the slight temporary electrization of the card converts into a continuous flood of intense electricity the force supplied by the arm of the operator.

These results offer great promise of extended application; they show that, by a mere formal disposition of matter, one force can be converted into another, and that not to the limited extent hitherto attained, but to an extent coordinate, or nearly so, with the increased initial force, so that, by a mere change in the arrangement of apparatus, a means of absorbing and again eliminating in a new form a given force may be obtained to an indefinite extent. As we may, in a not very distant future, need, for the daily uses of mankind, heat, light, and mechanical force, and find our present resources exhausted, the more we can invent new modes of conversion of forces, the more prospect we have of practically supplying such want. It is but a month from this time that the greatest triumph of force-conversion has been attained. The chemical action generated by a little salt water on a few pieces of zinc will now enable us to converse with inhabitants of the opposite hemisphere of this planet, and

"Put a girdle round about the earth in forty minutes."

The Atlantic Telegraph is an accomplished fact.

In physiology very considerable strides are being made by studying the relation of organized bodies to external forces; and this branch of inquiry has been promoted by the labours of Carpenter, Bence Jones, Playfair, E. Smith, Frankland, and others. Vegetables acted on by light and heat, decompose water, ammonia, and carbonic acid, and transform them into, among other substances, oxalate of lime, lactic acid, starch, sugar, stearine, urea, and ultimately albumen; while the animal reverses the process, as does vegetable decay, and produces from albumen, urea, stearine, sugar, starch, lactic acid, oxalate of lime, and ultimately ammonia, water, and carbonic acid.

As, moreover, heat and light are absorbed, or converted in forming the synthetic processes going on in the vegetable, so conversely heat and sometimes light is given off by the living animal; but it must not be forgotten that the line of demarcation between a vegetable and an animal is difficult to draw, that there are no single attributes which are peculiar to either, and that it is only by a number of characteristics that either can be defined.

The series of processes above given may be simulated by the chemist in his laboratory; and the amount of labour which a man has undergone in the course of twenty-four hours may be approximately arrived at by an examination of the chemical changes which have taken place in his body, changed forms in matter indicating the anterior exercise of dynamical force. That muscular action is produced or supported by chemical change would probably now be a generally accepted doctrine; but while many have thought that muscular power is derived from the oxidation of albuminous or nitrogenized substances, several recent researches seem to show that the latter is rather an accompaniment than a cause of the former, and that it is by the oxidation of carbon and hydrogen compounds that muscular force is supplied. Traube has been prominent in advancing this view, and experiments detailed in a paper published this year by two Swiss professors, Drs. Fick and Wislicenus, which were made by and upon themselves in an ascent of the Faulhorn, have gone far to confirm it. Having fed themselves before and during the ascent, upon starch, fat, and sugar, avoiding all nitrogenized compounds, they found that the consumption of such food was amply sufficient to supply the force necessary for their expedition, and that they felt no exhaustion. By appropriate chemical examination they ascertained that there was no notable

increase in the oxidation of the nitrogenized constituents of the body. After calculating the mechanical equivalents of the combustion effected, they then state, as their first conclusion, that "The burning of protein substances cannot be the only source of muscular power, for we have here two cases in which men performed more measurable work than the equivalent of the amount of heat, which, taken at a most absurdly high figure, could be calculated to result from the burning of the albumen."

They further go on to state that, so far from the oxidation of albuminous substances being the only source of muscular power, "the substances by the burning of which force is generated in the muscles, are not the albuminous constituents of those tissues, but non-nitrogenous substances, either fats or hydrates of carbon," and that the burning of albumen is not in any way concerned in the production of muscular power.

We must not confuse the question of the food which forms and repairs muscle and gives permanent capability of muscular force with that which supplies the requisites for temporary activity; no doubt the carnivora are the most powerfully constituted animals, but the Chamois, Gazelle, &c., have great temporary capacity for muscular exertion, though their food is vegetable; for concentrated and sustained energy, however, they do not equal the carnivora; and with the domestic graminivora we certainly find that they are capable of performing more continuous work when supplied with those vegetables which contain the greatest quantity of nitrogen.

These and many similar classes of research show that in chemical inquiries, as in other branches of science, we are gradually relieving ourselves of hypothetical existences, which certainly had the advantage that they might be varied to suit the requirements of the theorist.

Phlogiston, as Lavoisier said with a sneer, was sometimes heavy, sometimes light; sometimes fire in a free state, sometimes combined; sometimes passing through glass vessels, sometimes retained by them; which by its protean changes explained causticity and non-causticity, transparency and opacity, colours and their absence. As phlogiston and similar creations of the mind have passed away, so with hypothetic fluids, imponderable matters, specific ethers, and other inventions of entities made to vary according to the requirements of the theorist, I believe the day is approaching when these will be dispensed with, and when the two fundamental conceptions of matter and motion will be found sufficient to explain physical phenomena.

The facts made known to us by geological inquiries, while on the one hand they afford striking evidence of continuity, on the other, by the breaks in the record, may be used as arguments against it. The great question once was, whether these chasms represent sudden changes in the formation of the earth's crust, or whether they arise from dislocations occasioned since the original deposition of strata or from gradual shifting of the areas of submergence. Few geologists of the present day would, I imagine, not adopt the latter alternatives. Then comes a second question, whether, when the geological formation is of a continuous character, the different characters of the fossils represent absolutely permanent varieties, or may be explained by gradual modifying changes.

Prof. Ansted, summing up the evidence on this head as applied to one division of stratified rocks, writes as follows:—"Palæontologists have endeavoured to separate the Lias into a number of subdivisions, by the Ammonites, groups of species of those shells being characteristic of different zones. The evidence on this point rests on the assumption of specific differences being indicated by permanent modifications of the structure of the shell.

But it is quite possible that these may mean nothing more than would be due to some change in the conditions of existence. Except between the Marlstone and the Upper Lias there is really no palæontological break, in the proper sense of the words; alterations of form and size consequent on the occurrence of circumstances more or less favourable, migration of species, and other well-known causes sufficiently account for many of those modifications of the form of the shell that have been taken as specific marks. This view is strengthened by the fact that other shells and other organisms generally show no proof of a break of any importance except at the point already alluded to."

But, irrespectively of another deficiency in the geological record, which will be noticed presently, the physical breaks in the stratification make it next to impossible to fairly trace the order of succession of organisms by the evidence afforded by their fossil remains. Thus there are nine great breaks in the Palæozoic series, four in the Secondary, and one in the Tertiary, besides those between Palæozoic and Secondary and Secondary and Tertiary respectively. Thus in England there are sixteen important breaks in the succession of strata, together with a number of less important interruptions. But although these breaks exist, we find pervading the works of many geologists a belief, resulting from the evidence presented to their minds, sometimes avowed, sometimes unconsciously implied, that the succession of species bears some definite relation to the succession of strata. Thus Prof. Ramsay says that "in cases of superposition of fossiliferous strata, in proportion as the species are more or less continuous, that is to say, as the break in the succession of life is partial or complete, so was the time that elapsed between the close of the lower and the commencement of the upper strata a shorter or a longer interval. The break in life may be indicated not only by a difference in species, but yet more importantly by the absence of older and appearance of newer allied or unallied genera."

Indications of the connexion between cosmical studies and geological researches are dawning on us: there is, for instance, some reason to believe that we can trace many geological phenomena to our varying rotation round the sun; thus more than thirty years ago Sir J. Herschel proposed an explanation of the changes of climate on the earth's surface as evidenced by geological phenomena, founded on the changes of excentricity in the earth's orbit.

He said he had entered on the subject "impressed with the magnificence of that view of geological revolutions which regards them rather as regular and necessary efforts of great and general causes, than as resulting from a series of convulsions and catastrophes regulated by no laws and reducible to no fixed principles."

As the mean distance of the earth from the sun is nearly invariable, it would seem at first sight that the mean annual supply of light and heat received by the earth would also be invariable; but according to his calculations it is inversely proportional to the minor axis of the orbit: this would give less heat when the excentricity of the earth's orbit is approaching towards or at its minimum. Mr. Croll has recently shown reason to believe that the climate, at all events in the circumpolar and temperate zones of the earth, would depend on whether the winter of a given region occurred when the earth at its period of greatest excentricity was in aphelion or perihelion—if the former, the annual average of temperature would be lower; if the latter, it would be higher than when the excentricity of the earth's orbit were less or approached more nearly to a circle. He calculates the difference in the amount of heat at the period of maximum excentricity of the

earth's orbit to be as 19 to 26, according as the winter would take place when the earth was in aphelion or in perihelion. His reason may be briefly stated thus: assuming the mean annual heat to be the same, whatever the excentricity of orbit, yet if the extremes of heat and cold in winter and summer be greater, a colder climate will prevail, for there will be more snow and ice accumulated in the cold winter than the hot summer can melt—a result, aided by the shelter from the sun's rays, produced by the vapour suspended in consequence of the aqueous evaporation; hence we should get glacial periods, when the orbit of the earth is at its greatest excentricity, at those parts of the earth's surface where it is winter when the earth is in aphelion; carboniferous or hot periods where it is winter in perihelion; and normal or temperate periods when the excentricity of orbit is at a minimum; all these would gradually slide into each other, and would produce at long distant periods alternations of cold and heat, several of which we actually observe in geological records.

If this theory be borne out, we should approximate to a test of the time which has elapsed between different geological epochs. Mr. Croll's computation of this would make it certainly not less than 100,000 years since the last glacial epoch, a time not very long in geological chronology—probably it is much more.

When we compare with the old theories of the earth, by which the apparent changes on its surface were accounted for by convulsions and cataclysms, the modern view inaugurated by Lyell, your former President, and now, if not wholly, at all events to a great extent adopted, it seems strange that the referring past changes to similar causes to those which are now in operation should have remained uninvestigated until the present century; but with this, as with other branches of knowledge, the most simple is frequently the latest view which occurs to the mind. It is much more easy to invent a *Deux ex machinâ* than to trace out the influence of slow continuous change; the love of the marvellous is so much more attractive than the patient investigation of truth, that we find it to have prevailed almost universally in the early stages of science.

In astronomy we had crystal spheres, cycles, and epicycles; in chemistry the philosopher's stone, the elixir vitæ, the archæus or stomach demon, and phlogiston; in electricity the notion that amber possessed a soul, and that a mysterious fluid could knock down a steeple. In geology a deluge or a volcano was supplied. In palæontology a new race was created whenever theory required it: how such new races began, the theorist did not stop to inquire.

A curious speculator might say to a palæontologist of even recent date, in the words of Lucretius,

> "Nam neque de cœlo cecidisse animalia possunt
> Nec terrestria de salsis exisse lacunis.
> * * * * *
> E nihilo si crescere possent,
> (Tum) fierent juvenes subito ex infantibus parvis,
> E terrâque exorta repente arbusta salirent;
> Quorum nil fieri manifestum est, omnia quando
> Paulatim crescunt, ut par est, semine certo,
> Crescentesque genus servant"

—which may be thus freely paraphrased: "You have abandoned the belief in one primæval creation at one point of time, you cannot assert that an elephant existed when the first saurians roamed over earth and water. Without, then, in any way limiting Almighty power, if an elephant were created without progenitors, the first elephant must, in some way or other, have

physically arrived on this earth. Whence did he come? did he fall from the sky (*i. e.* from the interplanetary space)? did he rise moulded out of a mass of amorphous earth or rock? did he appear out of the cleft of a tree? If he had no antecedent progenitors, some such beginning must be assigned to him." I know of no scientific writer who has, since the discoveries of geology have become familiar, ventured to present in intelligible terms any definite notion of how such an event could have occurred: those who do not adopt some view of continuity are content to say God willed it; but would it not be more reverent and more philosophical to inquire by observation and experiment, and to reason from induction and analogy, as to the probabilities of such frequent miraculous interventions?

I know I am touching on delicate ground, and that a long time may elapse before that calm inquiry after truth which it is the object of associations like this to promote can be fully attained; but I trust that the members of this body are sufficiently free from prejudice, whatever their opinions may be, to admit an inquiry into the general question whether what we term species are and have been rigidly limited, and have at numerous periods been created complete and unchangeable, or whether, in some mode or other, they have not gradually and indefinitely varied, and whether the changes due to the influence of surrounding circumstances, to efforts to accommodate themselves to surrounding changes, to what is called natural selection, or to the necessity of yielding to superior force in the struggle for existence, as maintained by our illustrious countryman Darwin, have not so modified organisms as to enable them to exist under changed conditions. I am not going to put forward any theory of my own, I am not going to argue in support of any special theory, but having endeavoured to show how, as science advances, the continuity of natural phenomena becomes more apparent, it would be cowardice not to present some of the main arguments for and against continuity as applied to the history of organic beings.

As we detect no such phenomenon as the creation or spontaneous generation of vegetables and animals which are large enough for the eye to see without instrumental assistance, as we have long ceased to expect to find a Plesiosaurus spontaneously generated in our fish-pond, or a Pterodactyle in our pheasant-cover, the field of this class of research has become identified with the field of the microscope, and at each new phase the investigation has passed from a larger to a smaller class of organisms. The question whether among the smallest and apparently the most elementary forms of organic life the phenomenon of spontaneous generation obtains, has recently formed the subject of careful experiment and animated discussion in France. If it could be found that organisms of a complex character were generated without progenitors out of amorphous matter, it might reasonably be argued that a similar mode of creation might obtain in regard to larger organisms. Although we see no such phenomenon as the formation of an animal such as an elephant, or a tree such as an oak, excepting from a parent which resembles it, yet if the microscope revealed to us organisms, smaller but equally complex, so formed without having been reproduced, it would render it not improbable that such might have been the case with larger organic beings. The controversy between M. Pasteur and M. Pouchet has led to a very close investigation of this subject, and the general opinion is that when such precautions are taken as exclude from the substance submitted to experiment all possibility of germs from the atmosphere being introduced, as by passing the air which is to support the life of the animalculæ through tubes heated to redness and other precautions, no formation of organisms

takes place. Some experiments of Dr. Child's, communicated to the Royal Society during the last year, again throw doubt on the negative results obtained by M. Pasteur; so that the question may be not finally determined, but the balance of experiment and opinion is against spontaneous generation.

One argument presented by M. Pasteur is well worthy of remark, viz. that in proportion as our means of scrutiny become more searching, heterogeny, or the development of organisms without generation from parents of similar organism, has been gradually driven from higher to lower forms of life, so that if some apparent exceptions still exist they are of the lowest and simplest forms, and these exceptions may probably be removed, as M. Pasteur considers he has removed them, by a more searching investigation.

If it be otherwise, if heterogeny obtains at all, all will now admit that at present the result of the most careful experiments shows it to be confined to the most simple organic structures, such as vibrions and bacteria, and that all the progressive and more highly developed forms are, as far as the most enlarged experience shows, generated by reproduction.

The great difficulty which is met with at the threshold of inquiry into the origin of species, is the definition of species; in fact species can hardly be defined without begging the question in dispute.

Thus if species be said to be a perseverance of type incapable of blending itself with other types, or, which comes nearly to the same thing, incapable of producing by union with other types offspring of an intermediate character which can again reproduce, we arrive at this result, that whenever the advocate of continuity shows a blending of what had been hitherto deemed separate species, the answer is, they were considered separate species by mistake, they do not now come under the definition of species, because they interbreed.

The line of demarcation is thus *ex hypothesi* removed a step further, so that, unless the advocate of continuity can, on his side, prove the whole question in dispute, by showing that all can directly or by intermediate varieties reproduce, he is defeated by the definition itself of species.

On the other hand, if this, or something in fact amounting to it, be not the definition of species—if it be admitted that distinct species can, under certain favourable conditions, produce intermediate offspring capable of reproduction, then continuity in some mode or other is admitted.

The question then takes this form. Are there species or are there not? Is the word to be used as signifying a real, natural distinction, or as a mere convenient designation applied to subdivisions having a permanence which will probably outlive man's discussions on the subject, but not an absolute fixity? The same question, in a wider sense, and taking into consideration a much longer time, would be applicable to genera and families.

Actual experiment has done little to elucidate the question, nor, unless we can suppose the experiments continued through countless generations, is it likely to contribute much to its solution. We must therefore have recourse to the enlarged experience or induction from the facts of geology, palæontology, and physiology, aided by analogy from the laws of action which nature evidences in other departments.

The doctrine of gradual succession is hardly yet formularized, and though there are some high authorities for certain modifications of such view, the preponderance of authority would necessarily be on the other side. Geology and palæontology are recent sciences, and we cannot tell what the older authors would have thought or written had the more recently discovered facts been presented to their view. Authority, therefore, does not much help us on this question.

Geological discoveries seemed, in the early period of the science, to show complete extinction of certain species and the appearance of new ones, great gaps existing between the characteristics of the extinct and the new species. As science advanced, these were more or less filled up; the apparent difficulty of admitting unlimited modification of species would seem to have arisen from the comparison of the extreme ends of the scale where the intermediate links or some of them were wanting.

To suppose a Zoophyte the progenitor of a Mammal, or to suppose at some particular period of time a highly developed animal to have come out of nothing, or suddenly grown out of inorganic matter, would appear at first sight equally extravagant hypotheses. As an effort of Almighty creative power, neither of these alternatives presents more difficulty than the other; but as we have no means of ascertaining how creative power worked, but by an examination and study of the works themselves, we are not likely to get either side proved to ocular demonstration. A single phase in the progress of natural transmutation would probably require a term far transcending all that embraced by historical records; and on the other hand, it might be said, sudden creations, though taking place frequently, if viewed with reference to the immensity of time involved in geological periods, may be so rare with reference to our experience, and so difficult of clear authentication, that the non-observation of such instances cannot be regarded as absolute disproof of their possible occurrence.

The more the gaps between species are filled up by the discovery of intermediate varieties, the stronger becomes the argument for transmutation and the weaker that for successive creations, because the former view then becomes more and more consistent with experience, the latter more discordant from it. As undoubted cases of variation, more or less permanent, from given characteristics, are produced by the effects of climate, food, domestication, &c., the more species are increased by intercalation, the more the distinctions slide down towards those which are within the limits of such observed deviations; while on the other hand, to suppose the more and more frequent recurrence of fresh creations out of amorphous matter, is a multiplication of miracles or special interventions not in accordance with what we see of the uniform and gradual progress of nature, either in the organic or inorganic world. If we were entitled to conclude that the progress of discovery would continue in the same course, and that species would become indefinitely multiplied, the distinctions would become infinitely minute, and all lines of demarcation would cease, the polygon would become a circle, the succession of points a line. Certain it is that the more we observe, the more we increase the subdivision of species, and consequently the number of these supposed creations; so that new creations become innumerable, and yet of these we have no one well-authenticated instance, and in no other observed operation of nature have we seen this want of continuity, these frequent *per saltum* deviations from uniformity, each of which is a miracle.

The difficulty of producing intermediate offspring from what are termed distinct species and the infecundity in many instances of hybrids are used as strong arguments against continuity of succession; on the other hand, it may be said long-continued variation through countless generations has given rise to such differences of physical character, that reproduction is difficult in some cases and in others impossible.

Suppose, for instance, M to represent a parent-race whose offspring by ssive changes through cons of time have divaricated, and produced on io hand a species A, and on the other a species Z, the changes here have io great that we should never expect directly to reproduce an interme-

diate between A and Z. A and B on the one hand, and Y and Z on the other, might reproduce; but to regain the original type M, we must not only retrocede through all the intermediates, but must have similar circumstances recalled in an inverse order at each phase of retrogression, conditions which it is obviously impossible to fulfil. But though among the higher forms of organic structure we cannot retrace the effects of time and reproduce intermediate types, yet among some of the lower forms we find it difficult to assign any line of specific demarcation; thus as a result of the very elaborate and careful investigations of Dr. Carpenter on Foraminifera, he states, "It has been shown that a very wide range of variation exists among Orbitolites, not merely as regards external form, but also as to plan of development; and not merely as to the shape and aspect of the entire organism, but also with respect to the size and configuration of its component parts. It would have been easy, by selecting only the most divergent types from amongst the whole series of specimens which I have examined, to prefer an apparently substantial claim on behalf of these to be accounted as so many distinct species. But after having classified the specimens which could be arranged around these types, a large proportion would yet have remained, either presenting characters intermediate between those of two or more of them, or actually combining those characters in different parts of their fabric; thus showing that no lines of demarcation can be drawn across any part of the series that shall definitely separate it into any number of groups, each characterized by features entirely peculiar to itself."

At the conclusion of his inquiry he states,—

I. The range of variation is so great among Foraminifera as to include not merely the differential characters which systematists proceeding upon the ordinary methods have accounted specific, but also those upon which the greater part of the genera of this group have been founded, and even in some instances those of its orders.

II. The ordinary notion of species as assemblages of individuals marked out from each other by definite characters that have been genetically transmitted from original proto-types similarly distinguished, is quite inapplicable to this group; since even if the limits of such assemblages were extended so as to include what elsewhere would be accounted genera, they would still be found so intimately connected by gradational links, that definite lines could not be drawn between them.

III. The only natural classification of the vast aggregate of diversified forms which this group contains will be one which ranges them according to their direction and degree of divergence from a small number of principal family types; and any subordinate grouping of genera and species which may be adopted for the convenience of description and nomenclature must be regarded merely as assemblages of forms characterized by the nature and degree of the modifications of the original type, which they may have respectively acquired in the course of genetic descent from a common ancestry.

IV. Even in regard to these family types it may fairly be questioned whether analogical evidence does not rather favour the idea of their derivation from a common original than that of their primitive distinctness.

Mr. H. Bates, when investigating "The Lepidoptera of the Amazon Valley," may almost be said to have witnessed the origin of some species of Butterflies, so close have been his observations on the habits of these animals that have led to their variation and segregation, so closely do the results follow his observations, and so great is the difficulty of otherwise accounting for any of the observed facts.

In the numerous localities of the Amazon region certain gregarious species of Butterfly (Heliconidea) swarm in incredible numbers, almost outnumbering all the other butterflies in the neighbourhood; the species in the different localities being different, though often to be distinguished by a very slight shade.

In these swarms are to be found, in small numbers, other species of butterflies belonging to as many as ten different genera, and even some moths; and these intruders, though they structurally differ *in toto* from the swarms they mingle with, and from one another, mimic the Heliconideæ so closely in colours, habits, mode of flight, &c., that it is almost impossible to distinguish the intruders from those they mingle with. The obvious benefit of this mimicry is safety, the intruders hence escaping detection by predatory animals.

Mr. Bates has extended his observations to the habits of life, food, variations, and geographical range of the species concerned in these mimetic phenomena, and finds in every case corroborative evidence of every variety and species being derivative, the species being modified from place to place to suit the peculiar form of Heliconidea stationed there.

Mr. Wallace has done similar service to the derivative theory by his observations and writings on the Butterflies and Birds of the Malay Archipelago, adducing instances of mimetic resemblances strictly analogous to the above; and adding in further illustration a beautiful series of instances where the form of the wing of the same butterfly is so modified in various islets as to produce changes in their mode of flight that tend to the conservation of the variety by aiding its escape when chased by birds or predacious insects.

He has also adduced a multitude of examples of geographical and representative species, races, and varieties, forming so graduated a series as to render it obvious that they have had a common origin.

The effect of food in the formation and segregation of races and of certain groups of insects has been admirably demonstrated by Mr. B. D. Walsh, of North America.

Dr. McDonnell has been led to the discovery of a new organ in electric fishes from the application of the theory of descent, and Dr. Fritz Müller has published numerous observations showing that organs of very different structure may, through the operation of natural selection, acquire very similar and even identical functions. Sir John Lubbock's diving hymenopterous insect affords a remarkable illustration of analogous phenomena; it dives by the aid of its wings, and is the only insect of the vast order it belongs to that is at all aquatic.

The discovery of the Eozoon is of the highest importance in reference to the derivative hypothesis, occurring as it does in strata that were formed at a period inconceivably antecedent to the presupposed introduction of life upon the globe, and displacing the argument derived from the supposition that at the dawn of life a multitude of beings of high organization were simultaneously developed (in the Silurian and Cambrian strata).

Professor A. De Candolle, one of the most distinguished continental botanists, has, to some extent, abandoned the tenets held in his 'Géographie Botanique,' and favours the derivative hypothesis in his paper on the variation of oaks; following up a paper, by Dr. Hooker, on the oaks of Palestine, showing that some sixteen of them are derivative, he avows his belief that two-thirds of the 300 species of this genus, which he himself describes, are provisional only.

Dr. Hooker, who had only partially accepted the derivative hypothesis [illegible]nded before the publication of 'The Origin of Species through Natural

Selection,' at the same time declining the doctrine of special creation, has since then cordially adopted the former, and illustrated its principles by applying them to the solution of various botanical questions: first, in reference to the flora of Australia, the anomalies of which he appears to explain satisfactorily by the application of these principles; and, latterly, in reference to the Arctic flora.

In the case of the Arctic flora, he believes that originally Scandinavian types were spread over the high northern latitudes, that these were driven southwards during the glacial period, when many of them changed their forms in the struggle that ensued with the displaced temperate plants; that on the returning warmth, the Scandinavian plants, whether changed or not, were driven again northwards and up to the mountains of the temperate latitudes, followed, in both cases, by series of preexisting plants of the temperate Alps. The result is the present mixed Arctic flora, consisting of a basis of more or less changed and unchanged Scandinavian plants, associated in each longitude with representatives of the mountain flora of the more temperate regions to the south of them.

The publication of a previously totally unknown flora, that of the Alps of tropical Africa, by Dr. Hooker, has afforded a multitude of facts that have been applied in confirmation of the derivative hypothesis. This flora is found to have relationships with those of temperate Europe and North Africa, of the Cape of Good Hope, and of the mountains of tropical Madagascar and Abyssinia, that can be accounted for on no other hypothesis, but that there has been ancient climatal connexion and some coincident or subsequent slight changes of specific character.

The doctrine of Cuvier, every day more and more borne out by observation, that each organ bears a definite relation to the whole of the individual, seems to support the view of indefinite variation. If an animal seeks its food or safety by climbing trees, its claws will become more prehensile, the muscles which act upon those claws must become more developed, the body will become agile by the very exercise which is necessary to it, and each portion of the frame will mould itself to the wants of the animal by the effect on it of the habits of the animal.

Another series of facts which present an argument in favour of gradual succession, are the phases of resemblance to inferior orders which the embryo passes through in its development, and the relations shown in what is termed the metamorphosis of plants; facts difficult to account for on the theory of frequent separate creations, but almost inevitable on that of gradual succession. So also, the existence of rudimentary and effete organs, which must either be referred to a *lusus naturæ* or to some mode of continuous succession.

The doctrine of typical nuclei seems only a mode of evading the difficulty; experience does not give us the types of theory, and, after all, what are these types? It must be admitted there are none such in reality; how are we led to the theory of them? simply by a process of abstraction from classified existences. Having grouped from natural similitudes certain forms into a class, we select attributes common to each member of the class, and call the assemblage of such attributes a type of the class. This process gives us an abstract idea, and we then transfer this idea to the Creator, and make Him start with that which our own imperfect generalization has derived. It seems to me that the doctrine of types is, in fact, a concession to the theory of continuity or indefinite variability; for the admission that large groups have common characters shows, necessarily, a blending of forms within the scope of the group, which supports the view of each member being derived from some

other member of it: can it be asserted that the assigned limits of such groups have a definite line of demarcation?

The condition of the earth's surface or, at least, of large portions of it, has for long periods remained substantially the same; this would involve a greater degree of fixity in the organisms which have existed during such periods of little change than in those which have come into being during periods of more rapid transition; for, though rejecting catastrophes as the general *modus agendi* of nature, I am far from saying that the march of physical changes has been always perfectly uniform.

There have been doubtless what may be termed secular seasons, and there have been local changes of varying degrees of extent and permanence; from such causes organized beings would be more concentrated in certain directions than in others, the fixity of character being in the ratio of the fixity of condition. This would throw natural forms into certain groups which would be more prominent than others, like the colours of the rainbow, which present certain predominant tints though they merge into each other by insensible gradations.

While the evidence seems daily becoming stronger in favour of a derivative hypothesis as applied to the succession of organic beings, we are far removed from anything like a sufficient number of facts to show that, at all events within the existing geological periods capable of being investigated, there has been any great progression from a simpler or more embryonic to a more complex type.

Prof. Huxley, though inclined to the derivative hypothesis, shows, in the concluding portion of his address to the Geological Society, 1862, a great number of cases in which, though there is abundant evidence of variation, there is none of progression. There are, however, several groups of Vertebrata in which the endoskeleton of the older presents a less ossified condition than that of the younger genera. He cites the Devonian Ganoids, the Mesozoic Lepidosteidæ, the Palæozoic Sharks, and the more ancient Crocodilia and Lacertilia, and particularly the Pycnodonts and Labyrinthodonts, as instances of this when compared with their more recent representatives.

The records of life on the globe may have been destroyed by the fusion of the rocks, which would otherwise have preserved them, or by crystallization after hydrothermal action. The earlier forms may have existed at a period when this planet was in course of formation, or being segregated or detached from other worlds or systems. We have not evidence enough to speculate on the subject, but by time and patience we may acquire it.

Were all the forms which have existed embalmed in rock, the question would be solved; but what a small proportion of extinct forms is so preserved, and must be, if we consider the circumstances necessary to fossilize organic remains. On the dry land, unwashed by rivers and seas, when an animal or plant dies, it undergoes chemical decomposition which changes its form; it is consumed by insects, its skeleton is oxidized and crumbles into dust. Of the myriads of animals and vegetables which annually perish, we find hardly an instance of a relic so preserved as to be likely to become a permanent fossil. So again in the deeper parts of the ocean, or of the larger lakes, the few fish there are perish and their remains sink to the bottom, and are there frequently consumed by other marine or lacustrine organisms or chemically decomposed. As a general rule, it is only when the remains are silted up by marine, fluviatile or lacustrine sediments that the remains are preserved. Geology therefore might be expected to keep for us mainly such organic remains as inhabited deltas or the margins of seas, lakes, or rivers; here

and there an exception may occur, but the mass of preserved relics would be those of creatures so situated: and so we find it, the bulk of fossil remains consists of fish and amphibia, shell-fish form the major part of the geological museum, limestone and chalk rocks frequently consisting of little else than a congeries of fossil shells. Plants of reed or rush-like character, fish which are capable of inhabiting shallow waters, and saurian animals form another large portion of geological remains.

Compare the shell-fish and amphibia of existing organisms with the other forms, and what a small proportion they supply; compare the shell-fish and amphibia of Palæontology with the other forms, and what an overwhelming majority they yield.

There is nothing, as Prof. Huxley has remarked, like an extinct order of Birds or Mammals, only a few isolated instances. It may be said the ancient world possessed a larger proportion of fish and amphibia, and was more suited to their existence. I see no reason for believing this, at least to anything like the extent contended for; the fauna and flora now in course of being preserved for future ages would give the same idea to our successors.

Crowded as Europe is with cattle, birds, insects, &c., how few are geologically preserved! while the muddy or sandy margins of the ocean, the estuaries, and deltas are yearly accumulating numerous crustacea and mollusca, with some fishes and reptiles, for the study of future palæontologists.

If this position be right, then, notwithstanding the immense number of preserved fossils, there must have lived an immeasurably larger number of unpreserved organic beings, so that the chance of filling up the missing links, except in occasional instances, is very slight. Yet where circumstances have remained suitable for their preservation, many closely connected species are preserved—in other words, while the intermediate types in certain cases are lost, in others they exist. The opponents of continuity lay all stress on the lost and none on the existing links.

But there is another difficulty in the way of tracing a given organism to its parent form, which, from our conventional mode of tracing genealogies, is never looked upon in its proper light.

Where are we to look for the remote ancestor of a given form? Each of us, supposing none of our progenitors to have intermarried with relatives, would have had at or about the period of the Norman Conquest upwards of a hundred million direct ancestors of that generation, and if we add the intermediate ancestors, double that number. As each individual has a male and female parent, we have only to multiply by two for each thirty years, the average duration of a generation, and it will give the above result.

Let any one assume that one of his ancestors at the time of the Norman Conquest was a Moor, another a Celt, and a third a Laplander, and that these three were preserved while all the others were lost, he would never recognize either of them as his ancestor, he would only have the one-hundred millionth of the blood of each of them, and as far as they were concerned there would be no perceptible sign of identity of race.

But the problem is more complex than that which I have stated; at the time of the Conquest there were hardly a hundred million people in Europe, it follows that a great number of the ancestors of the *propositus* must have intermarried with relations, and then the pedigree, going back to the time of the Conquest, instead of being represented by diverging lines, would form a network so tangled that no skill could unravel it; the law of probabilities would indicate that any two people in the same country, taken at hazard, would not have many generations to go back before they would find a

common ancestor, who probably, could they have seen him or her in the life, had no traceable resemblance to either of them. Thus two animals of a very different form, and of what would be termed very different species, might have a common geological ancestor, and yet the skill of no comparative anatomist could trace the descent.

From the long continued conventional habit of tracing pedigrees through the male ancestor, we forget in talking of progenitors that each individual has a mother as well as a father, and there is no reason to suppose that he has in him less of the blood of the one than of the other.

The recent discoveries in palæontology show us that Man existed on this planet at an epoch far anterior to that commonly assigned to him. The instruments connected with human remains, and indisputably the work of human hands, show that to these remote periods the term civilization could hardly be applied—chipped flints of the rudest construction, probably, in the earlier cases, fabricated by holding an amorphous flint in the hand and chipping off portions of it by striking it against a larger stone or rock; then, as time suggested improvements, it would be more carefully shaped, and another stone used as a tool; then (at what interval we can hardly guess) it would be ground, then roughly polished, and so on,—subsequently bronze weapons, and, nearly the last before we come to historical periods, iron. Such an apparently simple invention as a wheel must, in all probability, have been far subsequent to the rude hunting-tools or weapons of war to which I have alluded.

A little step-by-step reasoning will convince the unprejudiced that what we call civilization must have been a gradual process; can it be supposed that the inhabitants of Central America or of Egypt suddenly and what is called instinctively built their cities, carved and ornamented their monuments? if not, if they must have learned to construct such erections, did it not take time to acquire such learning, to invent tools as occasion required, contrivances to raise weights, rules or laws by which men acted in concert to effect the design? Did not all this require time? and if, as the evidence of historical times shows, invention marches with a geometrical progression, how slow must have been the earlier steps! If even now habit, and prejudice resulting therefrom, vested interests, &c., retard for some time the general application of a new invention, what must have been the degree of retardation among the comparatively uneducated beings which then existed?

I have of course been able to indicate only a few of the broad arguments on this most interesting subject; for detailed results the works of Darwin, Hooker, Huxley, Carpenter, Lyell, and others must be examined. If I appear to lean to the view that the successive changes in organic beings do not take place by sudden leaps, it is, I believe, from no want of an impartial feeling; but if the facts are stronger in favour of one theory than another, it would be an affectation of impartiality to make the balance appear equipoised.

The prejudices of education and associations with the past are against this as against all new views; and while on the one hand a theory is not to be accepted because it is new and *primâ facie* plausible, still to this assembly I need not say that its running counter to existing opinions is not necessarily a reason for its rejection; the *onus probandi* should rest on those who advance a new view, but the degree of proof must differ with the nature of the subject. The fair question is, Does the newly proposed view remove more difficulties, require fewer assumptions, and present more consistency with observed facts than that which it seeks to supersede? if so, the philosopher will adopt it, the world will follow the philosopher—after many days.

It must be borne in mind that even if we are satisfied from a persevering and impartial inquiry that organic forms have varied indefinitely in time, the *causa causans* of these changes is not explained by our researches; if it be admitted that we find no evidence of amorphous matter suddenly changed into complex structure, still why matter should be endowed with the plasticity by which it slowly acquires modified structure is unexplained. If we assume that natural selection, or the struggle for existence, coupled with the tendency of like to reproduce like, gives rise to various organic changes, still our researches are at present uninstructive as to why like should produce like, why acquired characteristics in the parent should be reproduced in the offspring. Reproduction itself is still an enigma, and this great question may involve deeper thoughts than it would be suitable to enter upon now.

Perhaps the most convincing argument in favour of continuity which could be presented to a doubting mind would be the difficulty it would feel in representing to itself any *per saltum* act of nature. Who would not be astonished at beholding an oak tree spring up in a day, and not from seed or shoot? We are forced by experience, though often unconsciously, to believe in continuity as to all effects now taking place; if any one of them be anomalous we endeavour, by tracing its history and concomitant circumstances, to find its cause, *i. e.* to relate it to antecedent phenomena; are we then to reject similar inquiries as to the past? is it laudable to seek an explanation of present changes by observation, experiment, and analogy, and yet reprehensible to apply the same mode of investigation to the past history of the earth and of the organic remains embalmed in it?

If we disbelieve in sudden creations of matter or force, in the sudden formations of complex organisms now, if we now assign to the heat of the sun an action enabling vegetables to live by assimilating gases and amorphous earths into growing structures, why should such effects not have taken place in earlier periods of the world's history, when the sun shone as now, and when the same materials existed for his rays to fall upon?

If we are satisfied that continuity is a law of nature, the true expression of the action of Almighty Power, then, though we may humbly confess our inability to explain why matter is impressed with this tendency to gradual structural formation, we should cease to look for special interventions of creative power in changes which are difficult to understand, because, being removed from us in time, their concomitants are lost; we should endeavour from the relics to evoke their history, and when we find a gap not try to bridge it over with a miracle.

If it be true that continuity pervades all physical phenomena, the doctrine applied by Cuvier to the relations of the different parts of an animal to each other might be capable of great extension. All the phenomena of inorganic and organized matter might be expected to be so inter-related that the study of an isolated phenomenon would lead to a knowledge of numerous other phenomena with which it is connected. As the antiquary deduces from a monolith the tools, the arts, the habits, and epoch of those by whom it is wrought, so the student of science may deduce from a spark of electricity or a ray of light the source whence it is generated; and by similar processes of reasoning other phenomena hitherto unknown may be deduced from their probable relation with the known. But, as with heat, light, magnetism, and electricity, though we may study the phenomena to which these names have been given, and their mutual relations, we know nothing of what they are; so, whether we adopt the view of natural selection, of effort, of plasticity, &c., we know not why organisms should have this *nisus formativus*, or why the acquired habit or exceptional quality of the individual should reappear in the offspring.

Philosophy ought to have no likes or dislikes, truth is her only aim; but if a glow of admiration be permitted to a physical inquirer, to my mind a far more exquisite sense of the beautiful is conveyed by the orderly development, by the necessary inter-relation and inter-action of each element of the cosmos, and by the conviction that a bullet falling to the ground changes the dynamical conditions of the universe, than can be conveyed by mysteries, by convulsions, or by cataclysms.

The sense of understanding is to the educated more gratifying than the love of the marvellous, though the latter need never be wanting to the nature-seeker.

But the doctrine of continuity is not solely applicable to physical inquiries.

The same modes of thought which lead us to see continuity in the field of the microscope as in the universe, in infinity downwards as in infinity upwards, will lead us to see it in the history of our own race; the revolutionary ideas of the so-called natural rights of man, and *à priori* reasoning from what are termed first principles, are far more unsound and give us far less ground for improvement of the race than the study of the gradual progressive changes arising from changed circumstances, changed wants, changed habits. Our language, our social institutions, our laws, the constitution of which we are proud, are the growth of time, the product of slow adaptations, resulting from continuous struggles. Happily in this country, practical experience has taught us to improve rather than to remodel; we follow the law of nature and avoid cataclysms.

The superiority of Man over other animals inhabiting this planet, of civilized over savage man, and of the more civilized over the less civilized, is proportioned to the extent which his thought can grasp of the past and of the future. His memory reaches further back, his capability of prediction reaches further forward in proportion as his knowledge increases. He has not only personal memory which brings to his mind at will the events of his individual life,—he has history, the memory of the race; he has geology, the history of the planet; he has astronomy, the geology of other worlds. Whence does the conviction to which I have alluded, that each material form bears in itself the records of its past history, arise? Is it not from the belief in continuity? Does not the worn hollow on the rock record the action of the tide, its stratified layers the slow deposition by which it was formed, the organic remains imbedded in it the beings living at the times these layers were deposited, so that from a fragment of stone we can get the history of a period myriads of years ago? From a fragment of bronze we may get the history of our race at a period antecedent to tradition. As science advances our power of reading this history improves and is extended. Saturn's ring may help us to a knowledge of how our solar system developed itself, for it as surely contains that history as the rock contains the record of its own formation.

By this patient investigation how much have we already learned, which the most civilized of ancient human races ignored! While in ethics, in politics, in poetry, in sculpture, in painting, we have scarcely, if at all, advanced beyond the highest intellects of ancient Greece or Italy, how great are the steps we have made in physical science and its applications!

But how much more may we not expect to know?

We, this evening assembled, Ephemera as we are, have learned by transmitted labour, to weigh, as in a balance, other worlds larger and heavier than our own, to know the length of their days and years, to measure their enormous distance from us and from each other, to detect and accurately ascertain

the influence they have on the movements of our world and on each other, and to discover the substances of which they are composed; may we not fairly hope that similar methods of research to those which have taught us so much may give our race further information, until problems relating not only to remote worlds, but possibly to organic and sentient beings which may inhabit them, problems which it might now seem wildly visionary to enunciate, may be solved by progressive improvements in the modes of applying observation and experiment, induction and deduction?

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# REPORTS

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ON

# THE STATE OF SCIENCE.

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*Second Report of the Committee for Exploring Kent's Cavern, Devonshire. The Committee consisting of* Sir CHARLES LYELL, *Bart.*, Professor PHILLIPS, Sir JOHN LUBBOCK, *Bart.*, Mr. JOHN EVANS, Mr. EDWARD VIVIAN, *and* Mr. WILLIAM PENGELLY (Reporter).

In the First Report of the Committee, presented to the Association at the Meeting held at Birmingham in 1865, it was stated that Kent's Hole is situated in a small limestone hill about a mile eastward from Torquay harbour; that though it has been known from time immemorial, it did not attract the attention of scientific inquirers until the year 1824; that it was partially explored by the Rev. Mr. M'Enery from 1825 to 1829, by Mr. Godwin-Austen prior to 1840, and by the Torquay Natural History Society in 1846; and that all the explorers had been unanimous in stating that they found flint "implements," undoubtedly of human origin, mixed up with remains of extinct animals, in the ordinary cave-earth, beneath the floor of stalagmite.

Having briefly narrated the circumstances which led to the exploration of the cavern under the auspices of the British Association, the Committee proceeded to state that they had selected for the commencement of their researches the large Chamber into which the most southerly of the two external entrances opens, having been guided in their selection by the accessibility of the Chamber, and by the indispensable fact that the deposits it contained were certainly intact; that these deposits were, in descending order—1st, huge blocks of limestone which had fallen from the roof, and some of which were estimated to weigh 7 tons each; 2nd, black mould or mud, varying from 3 to upwards of 12 inches in thickness, and lying between and beneath the limestone blocks; 3rd, a stalagmitic floor, graduating downwards into a firm stony breccia, and averaging at least a foot in thickness; 4th, reddish ochreous loam, or "cave-earth," of unknown depth, having incorporated within it a large number of angular fragments of

limestone lying confusedly without anything like an approach to stratification or symmetrical arrangement; that blocks of limestone almost as large as those overlying the deposits were met with everywhere in the black mould, in the floor of stalagmite, and in the cave-earth; that though the stalagmite was everywhere firmly attached to the walls, a few instances occurred in which it did not extend quite across the Chamber, but that even in these exceptional cases the line of demarcation between the black mould and the cave-earth was sharp and well defined, there being no example of the commingling of the two; and that the presence of a calcareous drip was more or less traceable throughout the cave-earth.

They then described, somewhat in detail, the mode of exploration which had been followed uniformly from the beginning, and which rendered it easy to define accurately the position of every object of interest which had been met with,—that is to say, its distance in feet from the entrance of the Chamber; its distance in yards, right or left, from a "datum" line crossing the middle of the Chamber from the entrance to the back wall; and its depth in feet below the base of the stalagmite, to the extent of 4 feet, beyond which the excavation had not been carried.

Proceeding to a very general, but by no means exhaustive description of the contents of the various deposits, they stated that in the black mould were found numerous well-rounded pebbles, consisting of various kinds of rock, and probably derived from the neighbouring beaches; whetstones; pieces of slate, some of which were wrought into curvilineal shapes; a spoon, a fibula, a socketed celt, and other articles in bronze; a large fragment of a plate of smelted copper; numerous pieces of pottery which, though including one bit of Samian ware, were generally of a somewhat coarse character; a comb, a spoon, a chisel, and other objects formed of bone; spindle-whorls of various kinds of stone; a few flint-flakes; charred wood; bones of various animals, such as the pig, deer, sheep, badger, fox, hare, rabbit, small Rodents, bat, birds, and different kinds of fish; shells of different species of *Helix*, as well as of many of the marine forms common on the coast; and hazel-nuts, generally perforated at one end. That the few remains yielded by the stalagmitic floor included charred wood, land and marine shells, and bones of various animals—all probably of existing species. That from the cave-earth had been exhumed a very large number of bones of *Hyæna spelæa*, *Felis spelæa*, *Ursus spelæus*, *Rhinoceros tichorhinus*, *Elephas primigenius*, Fox, probably more than one species of Horse, and several species of Deer; that those of the Hyæna were the most numerous, after which, those of the Horse and Rhinoceros were, perhaps, about equally abundant; that the remains of the Mammoth were those of very young individuals*; that many of the bones occurred as fragments and mere splinters; that a large number of them were scored with the teeth-marks of various kinds of animals; that some of the long bones were split longitudinally; that some of those found beneath the large blocks of limestone were in a crushed condition; that most of them were of a chalk-like whiteness, a few only being discoloured; and that they were all of greater specific gravity than those found in the black mould. That lumps made up of cave-earth, small stones, comminuted bone, and matter of probably fæcal origin were numerous and widely distributed. That, rejecting doubtful specimens and mere chips, nearly thirty flint "implements" had been found in the undisturbed cave-earth, under

* Some of the teeth, &c., of *Elephas primigenius* found in the cavern by the early explorers belonged to fully-grown animals.

precisely the same conditions as the bones of the extinct animals with which they lay; that, with the exception of three, they were all of the kind denominated flakes, the excepted specimens being wrought to an edge all round their perimeters; that, like the bones, they were least numerous in the first foot below the stalagmite; and that those most elaborately wrought were found in the third and fourth foot-levels—the greatest depth to which the excavation had been carried.

In conclusion, the Committee stated that, unlike Mr. M'Enery, they had not succeeded in finding the remains of *Machairodus latidens* or of *Hippopotamus major*, nor had they detected any part of the human skeleton either in the cave-earth or in the overlying black mould, but that with these exceptions they had confirmed all the statements of the early explorers.

During the twelve months which have elapsed since the First Report, just recapitulated, was drawn up, the Committee have carried on their labours without interruption, the Superintendents have continued to visit the cavern daily, the original rigorous methods of excavation and examination have been uniformly followed, the results of each day's labour have been carefully registered, and at the commencement of every month a Report of progress has been forwarded to Sir Charles Lyell, the Chairman of the Committee.

The selected Chamber has been completely explored to the depth of 4 feet below the stalagmite. It measures about 62 feet from east to west, and something more than 30 from north to south. The limestone floor has been reached in several places, but elsewhere the deposits descend through wide fissures to probably considerable depths, and there is reason to believe that beneath the limestone there are extensive undervaultings.

In the inner or back wall of the Chamber, almost due west from the entrance, the workmen laid open the mouth of a Gallery, about 16 feet wide and extending westward for a distance of 29 feet, where it suddenly terminates in a mere slit in the limestone rock. This Gallery has also been excavated in the same manner and to the same depth as the Chamber.

A comparatively narrow passage leads out of the Chamber northwards, and must be traversed in proceeding, within the cavern, from one of the external entrances to the other. Mr. M'Enery termed it the "Passage of Urns," on account of the large amount of broken pottery which he there found in the black mould above the stalagmite. Since the completion of the exploration of the Gallery, the workmen have been occupied in excavating this Passage, a work now almost completed.

All the investigations of the Committee have been carried on in virgin ground. No traces of the earlier researches have been encountered, the deposits being everywhere indubitably intact.

Several blocks of limestone overlying the black mould have been met with in the Chamber and the Passage of Urns. Some of them were of great size, and one greatly surpassed the largest of those mentioned in the First Report. It measured 19½ feet long, 9 feet broad, and 2½ thick, or upwards of 430 cubic feet; so that its weight must have exceeded 30 tons. In order to the removal of this huge mass, it was necessary to blast it five times, each blast being very successful.

From their characters and positions, as well as from the condition of the roof, it is obvious that, from time to time, the blocks were severed naturally from the limestone strata, perhaps by the action of acidulated water along planes of jointage, such planes being prevalent and well defined in the

Devonian rocks of the district generally. No such masses were found on the floor of the Gallery.

The overlying black mould previously mentioned was found everywhere both in the Chamber and in the Passage of Urns; but not in the Gallery, except quite at the entrance, where there was a mere trace. It has continued to yield a large series of such articles as were mentioned in the First Report, few of which require to be particularized. The most interesting additions to the collection from this deposit are a series of spindle-whorls, a polishing stone, and a portion of a cake of smelted copper.

The whorls are six in number, and, unlike any of those mentioned in the First Report, are all formed of slate. Four of them are highly finished, and two are somewhat elaborately ornamented, but in different styles or patterns. No two of them are of the same size. The ornamented two were found lying together. Mr. Franks, of the British Museum, to whom they have been submitted, states that "the pattern on one of them resembles that on British pottery."

The "polishing stone" is a quadrantal fragment of an oblate spheroidal pebble of fine-grained quartzite, probably derived, directly or indirectly, from the famous "pebble-bed" occurring in the Triassic cliff immediately west of Budleigh Salterton, about thirteen miles north-easterly from the cavern. One of the flattened or polar surfaces, and also one of those at right angles to it, formed by the fracture of the stone, have undergone a considerable amount of artificial polish, as if they had been used in grinding, sharpening, or polishing. The stone was found under a large block of limestone, measuring 18 inches in thickness, and cemented with stalagmite to other such blocks.

The piece of copper differs from that mentioned in the First Report only in being smaller.

Some of the pottery found recently is so rotten as scarcely to bear handling, and when placed in water it resolves itself into a coarse mud.

As has been already observed, it was stated in the Report sent in last year that in a few instances the floor of stalagmite did not extend quite across the Chamber. These gaps entirely ceased at about 42 feet from the external entrance, so that in the innermost 20 feet of the Chamber, as well as throughout the entire Gallery, stalagmite occurred everywhere in unbroken continuity. Its level, however, instead of being uniformly the same, was, on the southern side of the Chamber, invariably somewhat lower than on the northern side. In other words, immediately in front or east of the Gallery, it suddenly sank below the general level which it attained elsewhere; but was, nevertheless, perfectly continuous with that which covered the other parts of the Chamber, without any indication of a line of fracture or severance. The Gallery possessed two such floors, or, as they were termed by way of distinction, a "floor" and a "ceiling." The former or lowermost, like that elsewhere, rested immediately on the red cave-earth, and towards its base gradually became a strong breccia. It varied from 3 inches to upwards of 2 feet in thickness, and was strictly a continuation of that part of the floor of the Chamber with which it was directly connected, and of which it was the immediate prolongation—that part, in fact, just stated to have been somewhat below the common level. The "ceiling," or uppermost floor, was of greater thickness. It extended from wall to wall across the Gallery without further support than that furnished by its own inherent cohesion. Its level was that of the general or comparatively high floor of the Chamber of which it was a continuation. Indeed a vertical north and south section through it showed that, at the

northern side of the mouth of the Gallery, the floor of the Chamber bifurcated and became two distinct floors, one above the other, and separated by an interspace which varied from 6 inches to nearly 4 feet in height—the uppermost being the "ceiling," on the common level; the lowermost the "floor," on the level of the depressed portion in the southern part of the Chamber.

Immediately above the "ceiling" there is in the limestone rock a considerable alcove. This branch of the cavern, therefore, is divided into three stories or flats—that below the "floor," occupied with cave-earth; that between the "floor" and "ceiling," entirely unoccupied; and that above the "ceiling," also without deposit of any kind.

The nether surface of the "ceiling" is of a beautifully stainless cream-colour, and sends down a profusion of small stalactites. When first disclosed, the "ceiling" was supposed to be a stratum of limestone *in situ*, completely invested with a mere film of stalagmite. In order to determine its true character, several holes were bored through it, when it was found to be exclusively stalagmite throughout—granular and comparatively soft in the upper part, but highly crystalline towards the base.

The origin of this mass is not a little puzzling; for whilst on the one hand it seems necessary to suppose that it was formed on a basis, either of limestone *in situ* or of detrital matter mechanically accumulated; on the other, it is difficult to understand how this basis could have been removed so completely as to leave behind no trace of stone or bone. Such "ceilings" occur in the famous Brixham Cavern on the opposite shore of Torbay, but to their lower surfaces there cling numerous stony and other relics of the deposits on which they were moulded. After a careful study of the case, the Superintendents of the exploration incline to the opinion that the "ceiling" was formed as a floor on a deposit of fine earth which once filled the Gallery to the necessary height, or, in other words, to the prevalent level of the deposit in the adjacent Chamber; that this deposit, either by a considerable subsidence or by being washed out, was completely detached from the floor which overlay it; and that subsequently a second and lower floor was formed in the Gallery, and additions were made to both the upper and the lower surfaces of the "ceiling" or first floor. In support of this opinion, it may be stated that the cream-coloured stalagmite forming the lower surface of the "ceiling," instead of being characteristic of the entire mass, is but a sort of "veneer," nowhere more than an inch thick. On being stripped off it is found that, both in texture and in colour, it is strongly contrasted with the material to which it was attached. The newly exposed surface, and the surface only, has the exact colour of the cave-earth; in fact it is soil-stained, and thus harmonizes well with the hypothesis. Again, the abruptly truncated character of its eastern end or commencement renders it not improbable that the "ceiling" is a remnant of a floor which formerly extended eastward into the Chamber, but which has there partially perished. Further, that a floor has been destroyed, either wholly or partially, is conclusively proved by the fact that a large number of fragments of stalagmite were met with, incorporated in the existing floor and also in the cave-earth below, both in the Chamber and in the Gallery.

In each branch of the cavern yet explored, bones of various animals and pieces of charred wood have been found in the stalagmite, but by no means abundantly. They have always been met with towards the base of the floor, and generally in the brecciated portion of it. The statement made in the First Report, that perhaps none of the animals represented in the stalagmite were

extinct, must be abandoned; for several teeth of *Hyæna spelæa*, *Rhinoceros tichorhinus*, and a species of Bear, probably *Ursus spelæus*, have occurred in it within the last twelve months, and, with one exception, all of them in the "floor" of the Gallery—a fact of considerable interest in connexion with the hypothesis that this floor is more modern than that found in the greater part of the Chamber.

The ordinary red cave-earth, with a plentiful admixture of angular fragments and blocks of limestone, has been met with everywhere beneath the stalagmite. Nowhere has there been the least approach to stratification or a symmetrical arrangement of materials. Nor has an instance occurred of the black mould beneath the floor, or of its being commingled with the red loam. In some localities the earth has been more, and in others less, abundant than the stones. Indeed, in a very considerable portion of the Passage of Urns the former was found very sparingly, the accumulation being almost entirely small pieces and blocks of limestone lying loosely together. In such cases the stalagmitic matter had occasionally infiltered between the stones to a depth of from 1 to 2 feet, or even more, below its general level. Besides the pieces of limestone, the red earth also contained fragments of rock neither derivable from the cavern hill nor, with the existing surface-configuration of the district, capable of being carried into the cavern by natural agency. None of them were angular, and most of them were well rounded. A very large proportion of them were pieces of different varieties of Devonian schistose grit, prevalent in the district, and found *in situ* in Lincombe Hill, which, immediately on the south-west, rises to the height of 372 feet above mean tide, or upwards of 180 feet above the cavern entrances. Quartz-pebbles are also more or less abundant, and, no doubt, were derived, commonly, from the vein-stones which traverse the grits just mentioned. Amongst them, however, there are one or two which, from the peculiarly vitreous aspect of the quartz, were probably derived from the crystalline schists composing the southern angle of Devonshire, and which, at their nearest approach, at the Start Point, are upwards of fifteen miles from the cavern. Nor are these the only examples of distantly derived materials, for well-rolled flints are by no means rare, and several examples of granitoid and other Dartmoor rocks have been met with. Many of these fragments are too small to have served any useful purpose, so that there is no probability of their having been selected by man. With the exception of such as occur on the recent, as well as the raised, beaches on the adjoining coasts, and occasionally in "pockets" and fissures in the limestone hills, the nearest locality in which flints are found *in situ* is Milbern Down, about five miles distant, where, overlying beds of greensand, is a considerable accumulation of supracretaceous gravel, mainly composed of flint and Dartmoor detritus. There can be no doubt that the granitoid pebbles found in the cavern were primarily derived from Dartmoor, which, where nearest, is at a distance of not less than twelve miles. It is possible, however, that these, and the rolled flint and fragments of vitreous quartz also, are relics of gravel once widely spread over south-eastern Devonshire, and of which that on Milbern Down, already mentioned, is the nearest existing remnant.

The uniform depth of four feet below the base of the stalagmite, to which the excavation of the cave-earth has been carried, by no means extends everywhere to one and the same level. The lowest level reached is in the Gallery, where the deposit presents some peculiar features. Whilst the first and second foot-levels consisted of the ordinary red earth with the usual admixture of angular fragments of limestone, the third and fourth feet, though

not quite destitute of the red loam, were to a very large extent made up of the *débris* of the schistose grit, in the form of sand, small angular flakes, and pebbles occasionally 3 inches in diameter.

As already stated, a large number of fragments of stalagmite were found embedded in the cave-earth. The first presented itself in the Chamber, at about 40 feet from the external entrance; and from this point inwards to the extremity of the Gallery they were more or less abundant. In the Chamber they occurred chiefly, but not exclusively, in that southern portion of which the Gallery may be regarded as the direct prolongation; in other words, in that part where, if anywhere, the original stalagmitic floor had been destroyed and replaced by a more modern one. Some of these masses were of great size, occasionally measuring 5 feet long, 4 broad, and 4 deep, or 80 cubic feet. They were generally composed of distinct laminæ of highly crystalline prisms, having their longest axes at right angles to the plane of lamination. In one or two instances only were there any stony fragments incorporated within, or attached to, them. In the Gallery they were confined to the upper 2 feet of the deposit, but in the Chamber they occupied all levels alike. Portions of stalactite were also frequently met with. An interesting case of this occurred at about 4 feet from the innermost end of the Gallery, where, within the first foot below the floor, there lay a fine slab of old stalagmite, having incorporated within it a fallen fragment of a conical pendant of stalactite, measuring 4 inches in diameter. Such examples are wonderfully calculated to convince the observer that the time during which the cave-earth was accumulated, though probably very protracted, was but a small portion of that represented by the entire history of the cavern. The case just mentioned takes the mind back to a time when a large stalactite, broken from the roof where it had slowly grown, fell on a floor of stalagmite which, in process of sealing up a subjacent deposit of detrital matter, had attained the thickness of about an inch. The fallen mass lay undisturbed where it fell, until the floor, increasing gradually, and with periods of intermittence, to the thickness of 7 inches, succeeded in investing it completely. Subsequently, but how long cannot be determined, the floor was broken up by natural causes, and many of its fragments were embedded in a new deposit. One of the broken masses, containing the stalactite previously mentioned, was lodged in a comparatively narrow branch of the cavern, and covered with about a foot of cave-earth. Over this accumulation was formed a new floor of stalagmite, in which lay teeth of *Hyæna spelæa*, *Rhinoceros tichorhinus*, and a species of bear. After this floor was completed, a comparatively black muddy soil, averaging a foot in thickness, was introduced.

Though a large number of bones have been found since the First Report was drawn up, they are by no means abundant everywhere. Thus remarkably few were met with in the third and fourth foot-levels in the Gallery; in other words, they were almost entirely absent in that part of the deposit in which cave-earth was but sparingly present. This is not ascribable to the comparatively contracted character of the Gallery, or the distance from the external entrances, for in the two upper feet they occurred in average abundance; indeed the last spadeful of true red loam found in the Gallery contained a fine canine of *Hyæna spelæa*. Again, in the Passage of Urns, near, and lying between, the two external entrances of the cavern, where, as has been stated, the deposit was almost exclusively made up of loose angular fragments of limestone, there were but few bones, and the few which did

occur lay in the small patches of cave-earth which here and there, chiefly in the lowest level, presented themselves. In short, though they occurred almost exclusively in the higher levels of the Gallery and the lowest of the Passage, in both they were found only where the cave-earth was found. Where the latter is present, but not elsewhere, bones may with considerable confidence be looked for.

Very many of the long bones have been split longitudinally, and, so far as is known, all the bones thus split, as well as many others, are distinctly scored with teeth-marks—probably those of the hyæna chiefly. It is difficult to suppose, either *à priori* or from an examination of them, that less than human agency could have so divided them, and it is obvious that unless they were gnawed soon after they were riven, they would scarcely be worth gnawing at all.

So far as is at present known, the labours of the last twelve months have failed to add a new species to the list of animals given in the First Report. Remains of Hyæna still preponderate; the Horse and Rhinoceros are probably next in prevalence; no bones of either Machairodus, Hippopotamus, or Man have yet been met with; and, with one exception, the elephantoid relics are those of small individuals. Three teeth of Elephant, probably *Elephas primigenius*, are remarkable for their diminutiveness, even when compared with the smallest of those mentioned last year. Indeed one of them is no more than eight-tenths of an inch long. The others are somewhat larger, but are interesting from being peculiarly narrow in proportion to their lengths, and from their plates standing out in prominent ridges on the lateral surfaces. They were all found in the fourth or lowest level, but in three distinct parallels.

Flint "implements" have been found in every branch of the cavern yet explored—the Chamber, the Gallery, and the Passage of Urns. In the last they were just as numerous as in the other branches, occurring amongst the loose stones, where bones failed to present themselves.

Omitting mere chips and very inferior specimens, upwards of 70 "implements" have been found since the First Report was drawn up, making, with those mentioned last year, something more than 100 specimens since the commencement of the exploration. About one-third of this total were met with in each of the first and second foot-levels below the stalagmite, and something more than one-sixth in the third foot. In short, up to this time, each level has been rather less productive than those above it—a statement differing from the corresponding one of last year.

The "implements" are divisible into three classes:—

1st. Mere *flakes*, probably struck off in making the more finished tools, but which, no doubt, would, from their sharp edges, be eminently useful for cutting or scraping.

2nd. *Lanceolate* "implements," pointed at one end and truncated at the other.

3rd. *Oval* "implements," convex on both sides, and worked to an edge all round the margin.

The largest specimen of the first class is nearly 5 inches long, and in greatest breadth and thickness measures $2\frac{1}{2}$ inches and 1 inch respectively. It is a portion of a nodule of coarse-grained light-grey flint, and in one part retains the original unfractured surface. As in the case of several others of the same class, its edges are so sharp and uninjured as to render it in the highest degree probable that it was struck off in the cavern,

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and had neither been used, nor exposed to the rolling or abrading action of water in motion. It was found in the Chamber, 53 feet from the external entrance, in the fourth foot-level below the stalagmite, which was from 12 to 15 inches thick and extended uninterruptedly for considerable distances in every direction.

The lanceolate "implements" are of two kinds—round-pointed and sharp-pointed. They are widest near the posterior extremity, and one surface has usually a central longitudinal ridge or keel, whilst the other is flat, or concave lengthwise, but which, whether flat or concave, appears almost invariably to have been produced at a single stroke. Of the round-pointed variety, a well-formed specimen was found in the Chamber, 46 feet from the entrance, in the upper part of the first level or foot of cave-earth, immediately below the stalagmite, which, at this part, was from one and a half to three feet thick. It measures about two inches long, and three-quarters of an inch broad; it is strongly carinated on one side, and longitudinally concave on the other. A second and still finer "implement" measures nearly three and a half inches long, rather more than one inch in greatest breadth, and four-tenths of an inch thick. It differs from the former in a few particulars. The central longitudinal ridge, at about an inch and a half from the hinder end, bifurcates symmetrically as if a small flake had been struck off. Hence the carinated side has three distinct surfaces, each of which is very slightly concave. There are several small facets, each produced, no doubt, by a separate and well-directed gentle stroke on the rounded anterior extremity, which seems too thick to render it probable that the "implement" could have been intended to be used as a spear-head. But for these facets, the "implement," though beautifully and very symmetrically shaped, appears to have required no more than four strokes for its formation; but in order to do this, the fracture must in each case have been remarkably clean. Indeed the beautiful smoothness by which all the surfaces are characterized suggests a doubt as to whether it may not have been produced by some degree of polishing. The small facets, however, are perhaps scarcely in keeping with this hypothesis. Its posterior extremity is not sharply truncated, but somewhat irregular, and both its lateral margins are slightly broken. It was found very near the centre of the Chamber, 2 feet deep in the red earth, and having over it a thick floor of stalagmite. Like the specimen previously described, it is formed of very fine-grained flint of a light cream-colour. On one side it is longitudinally concave.

The "implements" belonging to the second variety differ from these not only in being sharp-pointed, but in tapering more rapidly near the anterior extremity, in terminating in a thinner point, near which the keel, instead of being rectilineal, is gently curved, and the lateral margins, instead of being symmetrical, are one slightly convex and the other concave, conforming, in fact, to the deflection of the central ridge. In one specimen there are, on the flat side and near the point, several very small marginal facets. This fine "implement," or rather portion of one, is of whitened flint. It was found in the Chamber, 48 feet from the entrance, in the third level, beneath a thick floor of stalagmite.

Amongst the lanceolate "implements" there is one sharply truncated at both ends, the point probably having been broken off. It is 3 inches long, but when entire must have measured another inch; its greatest width somewhat exceeds 1 inch. The flat side has been produced by a series of blows, and suggests the ideas that the stroke which detached the "implement"

from the flint core left this a somewhat irregular surface; that a near approximation to flatness, and especially smoothness, on this side was essential to the performance of the work for which the tool was to be used; and that the requisite character was produced by numerous minute chippings carefully and skilfully directed. The obverse also contains evidence of a more than usual amount of work. It has two somewhat irregular and rudely parallel longitudinal ridges, as well as several facets. The lateral margins are not quite symmetrical. It is formed of fine-grained flint, of a light lead-colour inclining to whiteness; and it was found in the Chamber, 49 feet from the external entrance, 3 feet deep in the red deposit, and covered with a thick stalagmitic floor.

The only specimen of the third or ovoid class found since the First Report was presented is quite the finest "implement" which has been exhumed during the present exploration. It measures 4½ inches long, 3½ inches in greatest breadth, and about 1 inch in maximum thickness. It is strictly oval in form, being wider at one end than at the other. Like the fine "implements" of the same class described in the former Report, it is formed of a somewhat coarse-grained greyish flint. The bilateral symmetry of its outline is sensibly perfect. Its opposite faces differ somewhat in convexity; each of them, and especially that which is most convex, displays a large amount of chipping. This splendid tool was found 55 feet from the entrance, 8 feet from both the northern and the western wall of the Chamber, in the fourth foot of cave-earth, or the lowest yet excavated, beneath stalagmite which was about a foot thick and extended without a break for several yards in every direction; and it was dug out in the presence of one of the Superintendents and two gentlemen who accompanied him to the cavern.

Besides the foregoing "implements," all of which, as has been stated, were found in the Chamber, there is one which was met with 8 feet from the inner end of the Gallery, or 83 feet from the external entrance of the cavern; and which seems to connect the lanceolate and ovoid classes,—resembling the first in being pointed, and the second in being worked to an edge round its entire perimeter. Its dimensions are less than those of any oval, and its breadth, in proportion to its length, exceeds that of any lance-shaped "implement" which the cavern has yielded. It is 3 inches long, and in greatest breadth and thickness measures an inch and three-quarters and four-tenths of an inch respectively; it is nearly an inch and a quarter wide at the broad end, attains its maximum breadth about midway in its length, and has lost its extreme point. It is formed of fine-grained flint of a cream-colour, and differs from all the other cavern "implements" in having what may be conveniently termed a "varnished" or "glazed" surface. This "implement," which seems to have experienced rough usage, was found in the second foot-level below the stalagmite, which, in the Gallery, as already stated, is the lowest composed of true cave-earth.

Though, as has been stated, the lower levels have, on the whole, yielded fewer "implements" than the upper, it is still true that "those found in the third and fourth levels are the most highly wrought 'implements,'" and also that "those in the fourth or lowest zone are the most elaborately finished tools of the cavern series." In glancing over all that have been dug out during the present exploration, it appears that whilst there are several interesting tools from the first level, and a larger number from the second, neither of these zones has yielded an ovoid "implement;" that from the third belt were exhumed the first oval and the two best lanceolate forms; and that the

two oval tools found in the lowest level are very decidedly the most carefully finished specimens which the cavern has yielded. In the present stage of the investigation, the Committee think it neither desirable nor necessary to enter into any arguments to prove the artificial character of at least many of the flints which they have found. Indeed they speak for themselves; and in terms so unmistakeable that if they do not succeed in carrying conviction to the mind of the observer, any words that could be employed must certainly fail also.

It will be of interest, however, to call attention to certain other evidences of human existence found in the cave-earth. As already remarked, it was stated in the First Report that a whetstone had been found below the stalagmite. Very shortly after that Report was drawn up a second stone was met with, formed of a fragment of similar, though somewhat finer-grained, greenish grit. Its form is not quite the same as that of the first specimen. Mr. Franks states that "it closely resembles some stones found in the Bruniquel caves, in form and material." It was lying in the first level of cave-earth, 43 feet from the entrance, where the overlying stalagmite was 26 inches thick and extended many yards in every direction.

Several pieces of burnt bone were found in the cave-earth in the Gallery—some near the extreme, and others near its inner end. One of them was found in the first, and one in the third, but most of them in the second foot-level. In each case the deposit was overlain by a thick cake of stalagmite. Burnt bones have been found in the red earth in several parts of the Chamber also.

In conclusion, the Committee would remark that the careful and unremitting labour bestowed on the cavern during the last year and a half has produced a large accumulation of facts, consistent with one another and with those recorded by the earlier explorers. Of the discoveries made, the uniform testimony is that beneath a thick floor of stalagmite, so difficult to work as to require excellent tools and untiring perseverance, there are everywhere found, inosculating with bones of extinct mammals, and undoubtedly inhumed at the same time, human industrial remains, of a character so humble and so little varied as to betoken a very low type of civilization.

## *Preliminary Report on the Chemical Nature of Cast Iron.*
### *By* A. MATTHIESSEN, *F.R.S.*

In the Transactions of the British Association for 1863 it was pointed out, in a "Report on the Chemical Nature of Alloys," that alloys may be, when in a solid state,—

(1) Solidified solutions of the one metal in the other;
(2) Chemical combinations;
(3) Solidified mechanical mixtures;
(4) Or solidified solutions of mixtures of any of these.

It is important to clearly understand what is here meant by the term "solidified solution," for in speaking of alloys they are generally considered to be either mechanical mixtures or chemical combinations. In the "Report

on the Chemical Nature of Alloys," I have defined the terms "solution of one metal in the other, as one like that of ether and alcohol; for these two liquids may be mixed in any proportion, and they will not separate, by standing, into two layers," and "solidified solutions as a most intimate mixture, such as would occur in the sudden conversion of a solution of two liquids into a solid, and a much more intimate mixture than can be obtained by ordinary mechanical means—in fact a perfectly homogeneous diffusion of one body in another. An excellent example of homogeneous diffusion is furnished by glass, which is formed in a liquid state at a high temperature, and solidifies on cooling without separation of the different silicates."

Before deducing the chemical nature of cast iron from what is already known, it will be as well to compare the physical deportment of the alloys of carbon and iron with that of other alloys; for instance, with those of tin and copper, and zinc and copper. Pure iron is said to be very malleable, so is pure copper; iron alloyed with small quantities of carbon (malleable, wrought iron) is less malleable and harder than the pure metal; so is copper, when alloyed with small quantities of tin or zinc, less malleable and harder than the pure metal. Iron alloyed with from 1 to 2 per cent. of carbon has obtained its maximum state of hardness in conjunction with a certain degree of malleability and ductility (steel); copper alloyed with certain quantities of tin or zinc possesses similar properties, forming gun-metal and brass.

Again, increase the amount of carbon in the iron and the mass becomes brittle and unworkable (cast iron); so also do the alloys of copper, and tin or zinc, when the amount of the latter exceeds that contained in gun-metal or brass by a few per cent.

Leaving out of consideration the impurities of cast iron, let us first discuss the alloys of carbon and iron, and these we find may be divided into two classes, viz. the white and the grey cast iron.

Now the essential difference between these two forms is the state in which the carbon exists in them. In the one (white) it is said to be chemically combined with the iron, in the other (grey) mechanically mixed with the iron. As these, the white and the grey iron, may be converted into one another by re-fusion (for if certain sorts of white iron be fused at a low temperature and allowed to cool slowly, grey will be produced, and conversely, if grey iron be fused at a high temperature and cooled rapidly, white iron), it follows that the chemical combination of carbon and iron may be made to split up into its component elements simply by slowly cooling the molten mass. Bearing on this point are the following experiments made by Karsten: he took a mass of cast iron and determined the amounts of so-called chemically combined and uncombined (graphitic) carbon in it; he then melted it and cast it in a mould, analyzed the outer and inner portion of it. The following are the results he obtained:—

| | Carbon per cent. | |
|---|---|---|
| | Combined. | Uncombined. |
| Before melting ..... | 0·78 | 3·25 |
| Outer (white) portion of casting ..... | 5·10 | —— |
| Inner (grey) portion of casting ..... | 0·61 | 3·16 |

Now, can it be possible that the carbon is really chemically combined with the outer portion of the casting and not in the inner? if this be so, it is I think the only case known of a chemical combination in which the elements

are so loosely held together that the various rates of cooling will determine their combination or decomposition.

From the analogy of the alloys of carbon and iron with other alloys, it is possible that the case is as follows; namely, that the carbon and iron exist in the molten state as a solution of the one in the other—when in the white state as a solidified solution of carbon in iron, and when in the grey state as a mechanical mixture of carbon and iron.

If the above assumption be correct, then the conversion of white into grey cast iron, and *vice versâ*, may be easily explained; for if in the liquid state the carbon and iron be only a solution of carbon and iron, then we can easily understand why the carbon, when the molten mass is heated to a high temperature and cooled slowly, crystallizes out, and when cooled quickly, not having time to crystallize out, remains homogeneously diffused through the iron; as it is very probable that molten iron will dissolve more carbon at higher temperatures than at lower ones.

The two chief reasons for assuming that the carbon and iron exist in the state of chemical combination are,

(1) That when white iron is dissolved in dilute acids, the carbon combines with the hydrogen, forming carburetted hydrogen.

(2) That different carbides of iron have been isolated.

First, respecting the chemical behaviour of the carbon in the white iron, the following remarks may be made. If it be assumed that the carbon in cast iron is homogeneously diffused through the mass, then it must be in an exceedingly fine state of division—in fact in just the state for combining with other bodies; for it is well known that carbon as well as other substances possess properties, when in a state of fine division, which they do not possess when in a more coherent form. Thus in the case of carbon, the more porous it is the more active it becomes in dechlorizing liquids and absorbing and condensing gases in its pores. Platinum is also a good example of this fact; in a dense form, as in foil, it only possesses the property of condensing gases on its surface to a very feeble extent; in its spongy form it possesses this property in a very marked degree, and as platinum-black possesses it to a far greater extent than the spongy modification.

As another example of the influence of the chemical activity of bodies when in a fine state of division, we may take the cases of iron, lead &c., these metals, when in a coherent form, undergoing when exposed to the atmosphere only a very slow oxidation, but when in a very fine state of division (reduced oxides) combining with oxygen instantly.

The chemical behaviour of the constituents of alloys is sometimes different when in an alloy from what it is when alone; thus platinum when alloyed with silver dissolves to a certain extent in nitric acid. Now, taking the determinations of the conducting-powers of alloys as a means of testing their chemical constitution, I should with certainty say that there exists in the alloys of platinum with silver no chemical combination, for their observed and calculated conducting-powers agree together better than for any other series of alloys. The curves representing the conducting-powers of the alloys of these metals with one another possess the typical form of the alloys of that class of metals to which these belong.

2ndly. With regard to the definite chemical combinations which have been isolated from cast iron, it may be remarked that definite crystalline forms with alloys do not necessarily indicate chemical combinations. Cooke*, I believe,

* Memoirs of the American Academy (new series), vol. viii. p. 27.

was the first to point out this fact with regard to alloys, in a paper on the alloys of antimony and zinc. He showed that those containing 43 to 64 per cent. of zinc all crystallize in the same form, but differently from the other alloys. With the alloys of gold and tin it has been shown* that well-defined crystals are not limited to definite proportions of the constituents, but are common to all gold and tin alloys containing from 27 to 43 per cent. of gold; and that crystals and mother-liquor never are of the same composition. Storer† has also experimentally proved that all the copper and zinc alloys crystallize in the same form.

These facts show that the crystalline alloys of carbon and iron do not prove the existence of chemical combination between them, more especially when we consider that several definite crystalline compounds of carbon and iron have been obtained. In all probability, by altering the conditions of cooling, &c., crystals of iron containing various amounts of carbon may be obtained from the same sample of cast iron. For the chemical combination theory of cast iron we have—

(1) The evolution of carburetted hydrogens when white cast iron is treated with dilute acids.

(2 The existence of definite crystalline forms of carbon and iron.

Against it—

(1) The analogy of the alloys of carbon and iron with the other alloys.

(2) The fact of carbon in such a fine state of division that it may exist in white iron (solidified solution) and may be able to unite with hydrogen at the moment of being set free (as in the case of platinum-silver alloys, where a portion of the platinum is dissolved by nitric acid).

(3) We know of no other case where with two elements the different rates of cooling determine the chemical combination or decomposition (conversion of white into grey and grey into white cast iron).

(4) That with alloys definite crystalline forms are not necessarily chemical combinations.

That iron in a molten state will not dissolve more than about 5 per cent. of carbon is analogous to the cases of lead and zinc, bismuth and zinc, mercury and zinc. For it has been shown ‡ that pure lead will only dissolve 1·6 per cent. a pure zinc, and pure zinc 1·2 per cent. of pure lead; that pure zinc will only dissolve 2·4 per cent. pure bismuth, and pure bismuth from 8·6 to 14·3 per cent. pure zinc§.

Now, although no actual determinations have been made, we may suppose that the solvent power in the above-mentioned cases of the one metal for the other at higher temperatures will be greater than at lower ones; hence, for instance, zinc (containing a small percentage of lead) might possibly be made to crystallize from a molten alloy of lead and zinc, containing, say, from 2 to 2·5 per cent. zinc.

Supposing the metals lead and zinc be melted together in equal parts, what takes place? The zinc (according to the temperature) takes up a certain amount of lead, and floats upon the lead which has taken up a certain amount (according to the temperature) of the zinc. If these two alloys were intimately mixed together (by stirring or shaking) and cooled rapidly, we might suppose that under certain conditions an almost homogeneous mixture might be obtained; or supposing we were rapidly to cool a solution of zinc

* Memoirs of the American Academy (new series), vol. v. p. 337.
† Proc. Roy. Soc. vol. xi. p. 433. ‡ *Ibid.* p. 430. § *Ibid.*

in lead, we should produce a solid mass similar to what we termed a solidified solution.

Again, if only a few per cent. of tin be added to the mixture, of, say, ten parts zinc in lead, a perfect alloy will be formed.

Applying these facts to the alloys of carbon and iron, we are led:—

(1) To look upon white iron (containing small percentages) as a solidified solution of carbon and iron;

(2) When containing larger percentages as a solidified solution of carbon and iron, with carbon diffused through the mass in a very fine state of division;

(3) When containing large percentages of carbon, together with certain other substances (manganese, to wit), as a solidified solution of carbon, iron, and the other substances.

And to look on the grey modification as a solidified solution of carbon and iron, with carbon (varying amounts of the graphitic modification) mechanically intermixed.

Another point in favour of the above may be mentioned, namely, that it has been observed that the conducting-power of the pure metal may be deduced from that of the impure one, where the conducting-power of the impure metal differs from that of the pure one by not more than 20 per cent.; this has been found to hold good only in cases where solidified solutions exist.

Now some experiments* have been made in this direction with various kinds of iron. The results obtained were as follows:—

Specific conducting-power in terms of the B.A. unit for metre length and millimetre diameter.

| No. | Observed. | Deduced for pure metal. |
|---|---|---|
| 5 | 7·472 | 8·207 |
| 6 | 7·438 | 8·191 |
| 7 | 6·755 | 7·863 |
| 9 | 7·002 | 7·898 |
| 13 | 6·322 | 7·855 |
| 15 | 6·551 | 7·950 |

The amount of impurities in 5, 6, 7 were, in 100 parts,—

| | 5. | 6. | 7. |
|---|---|---|---|
| Sulphur | 0·190 | 0·121 | 0·104 |
| Phosphorus | 0·020 | 0·178 | 0·106 |
| Silicium | 0·014 | 0·160 | 0·122 |
| Carbon | 0·230 | 0·040 | 0·020 |
| Manganese, Nickel, Cobalt | 0·110 | 0·029 | 0·280 |

No. 9. From a piece of sheet-iron.
No. 13. Pianoforte wire.
No. 15. Commercial iron wire.

These data show that the alloys of iron follow in this respect the same laws as those of other metals.

* Phil. Trans. 1864, p. 369.

To see whether the above assumptions, as to the chemical nature of cast iron, are correct, it is proposed—

(1) To make some pure iron.

(2) To alloy the pure iron with various amounts of carbon and to test the physical and chemical properties of these alloys.

(3) To alloy the pure iron in different proportions with other metals and metalloids.

From the forgoing considerations I expect to be able to produce analogous alloys to iron and carbon with some of the other metals, having the peculiar properties of cast iron, steel, and wrought iron; and probably some may be found to be much better adapted for certain purposes than the alloys of carbon and iron—for instance less liable to become crystalline by age, &c.

(4) To alloy the pure iron with various amounts of carbon, and to add to these alloys such substances as are found in the commercial irons so as to study their respective effects on the physical and chemical nature of cast iron, and more especially on their influence on the solvent power of iron for carbon.

It is intended to investigate carefully the action of dilute and strong acids on the various alloys of iron and carbon, in order to see how far, and under what conditions, the carbon is evolved as carburetted hydrogen.

The experiments will be made on a small scale, fusion taking place in one of Deville's oxyhydrogen furnaces, which gives an admirable means of experimenting with refractory metals.

The pure iron will partly be prepared from the oxalate, and partly by the electrotype process, and fused in lime crucibles.

The experiments have already been commenced, and I hope at the next Meeting of the Association to report good progress.

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*Report on Observations of Luminous Meteors,* 1865–66. *By a Committee, consisting of* James Glaisher, *F.R.S., of the Royal Observatory, Greenwich, Secretary to the British Meteorological Society, &c.;* Robert P. Greg, *F.G.S., &c.;* E. W. Brayley, *F.R.S., &c.; and* Alexander S. Herschel, *B.A.*

The Committee have the satisfaction to present in their Report a marked degree of progress over their success in former years. Observations of three large meteors, at the Royal Observatory, Greenwich, have been confirmed by descriptions of observers at distant places, so that the height and velocity of the meteors could be conclusively determined (Appendix I. 1, 2, 4); and the accounts of meteors continually communicated by observers to the Committee have led in other cases to obtaining the same satisfactory result.

The Committee are particularly indebted to Mr. Warren De la Rue for a collection of excellent descriptions of the detonating fireball of the 21st of November 1865, placed by Mr. Warren De la Rue at the disposal of the Committee, by which the earth-distance, the velocity, and the direction of this meteor in space could be determined.

Exact determinations of the height, and other particulars of large meteors in different parts of the globe, are collected in this Report, following the catalogue, in Appendix II. Remarkable statements regarding the large

detonating meteor which appeared over the Dover Straits on the forenoon of the 20th of June 1866, with instrumental measurements of its apparent path by Mr. Francis Galton, will be found in this Appendix.

The object of the Committee in providing star-charts to observers of the meteoric shower of November last, was attained; and accurate observations of luminous meteors under that date are presented in the Catalogue of the Report. The radiant-point of the meteoric shower, during the period of its greatest activity, was situated within two degrees of the place which it occupied in the interval of the greatest meteoric activity of the same shower in the year 1833—a fact in itself demonstrative of the fixed uranographical character of the phenomenon (Appendix IV. 2).

The height of the November meteors is shown in this Report to be the same as that of ordinary shooting-stars, or about sixty miles above the surface of the earth; whilst with regard to their speed, they are three times swifter than those meteors which at the same time arrive from the direction of the constellation Taurus.

Bearing in mind the strong probability that exists of the occurrence in the present year of a more extraordinary meteoric shower, on the morning of the 13th or on the morning of the 14th of November, than any that has yet been observed at the English observatories, the Committee during the past year judged it unadvisable to incur avoidable expense, or to exceed the means at their command by lithographing the charts of general radiant-points of shooting-stars, exhibited two years ago at Bath, to the Meeting of the British Association, and these they now suggest might be printed, and distributed with advantage.

The occasion of the return of the great November shower being one of very rare occurrence, the Committee, with the view of profiting by the opportunity thus afforded of observing the spectra of luminous meteors, have this year provided themseves with spectroscopes, and have succeeded in analyzing the light of shooting-stars by means of their prismatic spectra. Two spectroscopes were directed to be prepared by Mr. Browning, and were first used on the 10th of August last, and seventeen spectra were observed. A description of the observations, together with the discovery of the yellow sodium-line as the chief feature of the greater number of the train-spectra, will be found in the last Appendix of the Report.

## A CATALOGUE OF OBSERVATIO

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, Altitude a Azimuth |
|---|---|---|---|---|---|---|
| 1768. Dec. 23 | h m 7 0 a.m. | S. Atlantic ..... | Large ..... | ..... | ..... | In the W. ... |
| 1856. Aug. 6 and Aug. 11 | 10 45 to 11 15 p.m. 1 45 to 3 15 a.m. | Hawkhurst (Kent). | ..... | ..... | ..... | ..... |
| 1858. Sept. 25 | Evening ... | Lucknow, India.. | Large as a 'broom' or a comet. | Pale green ... | A very few seconds; very rapid. | First appeared head, and ed near the rizon. |
| 1865. Apr. 29 | 8 10 p.m. | Weston-super-Mare. | Large ..... | ..... | ..... | A little N. of |
| June 12 | Midnight... | Hawkhurst (Kent). | ..... | ..... | ..... | ..... |
| July 3 | 10 53 p.m. | Ibid ..... | =2nd mag.* ..... | Orange yellow | 1·3 second ... | Commenced Camelopardi. |
| 4 | 1 5 a.m. | ..... | =3rd mag.* ..... | Yellow ..... | 0·4 second ... | Began midway tween ρ Ca peiæ and phei. |

## LUMINOUS METEORS.

| ance; Train, if any, d its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| a small white cloud d a train of fire. | ..... | E. to W. ..... | Followed at an interval of two minutes by two loud explosions like cannon, after which the cloud soon disappeared. | 'Cook's Voyage round the World.' (See Appendix II.) |
| ..... | ..... | ..... | Aug. 6th, eight meteors in 30 minutes; three of the largest shot precisely from Cassiopeia; a superb clear night; one observer. Aug. 11th, a.m., fifty meteors in $1^h\ 30^m$; several very large and brilliant, with fine trains; sky partially cloudy; two observers. "A few only were 'sporadic;' but by far the greater majority diverged from a region *near*, but not *in* Cassiopeia. On the whole, I should assign the cluster in the sword-handle of Perseus, or a place some 2° or 3° north of that spot, for the vanishing-point. Catches of distant lightning all night, though from $1^h$ to $3^h$ a.m. there was not a cloud in the sky." | J. F. W. Herschel, MS. |
| a flame. It passed ind a strip of cloud, appearing and aparing again as quick tl ought. | ..... | ..... | The Sepoys said that it was as a 'gharoo' (broom or comet), to sweep away the Delhi or Lucknow raj. | J. S. A. Herbert, 'Stirring times under Canvas' (p. 230). |
| ..... | ..... | ..... | Fell somewhat obliquely | Communicated by W. H. Wood. |
| ..... | ..... | ..... | No shooting-star visible in 15 minutes: clear sky; no moon; one observer. | A. S. Herschel. |
| ..... | 15° ..... | Directed from γ Cassiopeiæ. | ..... | Id. |
| ..... | 8° ..... | Directed from ε Honorum. | In one hour (12.15 to 1.15 a.m.) one meteor only: clear sky; no moon; one observer. | Id. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, or Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1865. July 5 | h m Evening ... | Pietermaritzburg, Natal, S. Africa. | Very large ..... | ..... | ..... | ..... |
| 12 | 9 57 p.m. | Langdale, Westmoreland. | Brighter than Venus. | ..... | ..... | In the west part the sky; altitu about 20° or 3 |
| 15 | 11 40 p.m. | Hawkhurst (Kent). | =3rd mag.* ..... | White ..... | 0·7 second ... | Commenced at Herculis. |
| 15 | 11 42 p.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·7 second ... | Disappeared at Coronæ. Cou halfway from Herculis. |
| 16 | 0 28 a.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·7 second ... | Commenced at (I, θ) Aquilæ. |
| 16 | 0 42 a.m. | Ibid ..... | =1st mag.* ..... | White ..... | 0·9 second ... | Disappeared at Coronæ. Cou halfway from Herculis. |
| 20 | 0 52 a.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·8 second ... | From λ to α A dromedæ. |
| 20 | 0 53 a.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·3 second ... | From π Tara to M Camel pardi. |
| 20 | 0 55 a.m. | Ibid ..... | =3rd mag.* ..... | Dull ..... | 0·4 second ... | From β, halfway ι Cephei. |
| 20 | 1 5 a.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·5 second ... | From ι Ceph halfway to Custodis. |
| 20 | ..... | Ibid ..... | =3rd mag.* ..... | White ..... | 0·5 second ... | From r Custod halfway to N laris. |
| 20 | 1 11 a.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·7 second ... | From α Lyræ to Draconis. |
| 20 | ..... | Ibid ..... | =3rd mag.* ..... | White ..... | 0·6 second ... | From f to ε N gasi. |
| 20 | 1 18 a.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·4 second ... | From α to η C phei. |
| 20 | 1 21 a.m. | Ibid ..... | =3rd mag.* ..... | Dull ..... | 0·5 second ... | Began at ε Pegas |
| Aug. 2 | 11 50 p.m. | Southampton ... | =3rd mag.* ..... | Yellow ..... | 0·8 second ... | From ½ (θ S pentis, ζ Aqua to ½ (β, γ) C uchi. |
| 3 | 12 14 a.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·6 second ... | From near σ C phei. |

| rance; Train, if any, d its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| ..... | ..... | ..... | "A very magnificent meteor burst over Maritzburg on the evening of the 5th. This meteor passed from east to west, and was attended by a loud report. It was seen beyond Fort Nottingham, quite up to the base of the Drakensberg. An interval, differently estimated between one and three minutes, intervened between the flash of light and the sound." | Dr. Mann, Abstract of Meteorological Observations at Pietermaritzburg, 1865. |
| long streak behind it | ..... | ..... | ..... | J. C. Melville. |
| ..... | 10° ..... | Directed from $\delta$ Herculis. | ..... | A. S. Herschel. |
| ..... | ..... | ..... | ..... | Id. |
| a streak for 1 second | 10° ..... | Directed from $\iota$ Pegasi. From a radiant in Perseus. | ..... | Id. |
| ..... | ..... | ..... | ..... | Id. |
| ..... | ..... | ..... | ..... | Id. |
| ..... | ..... | ..... | ..... | Id. |
| ..... | ..... | ..... | ..... | Id. |
| ..... | ..... | ..... | ..... | Id. |
| ..... | ..... | ..... | ..... | Id. |
| ..... | ..... | ..... | ..... | Id. |
| ..... | ..... | ..... | ..... | Id. |
| rain or sparks ..... | ..... | Directed from $\pi_1$ Cygni | ..... | Id. |
| ..... | ..... | ..... | Swift meteor ..... | Id. |
| a streak for 1 second | 8°..... | Directed from $\delta$ Cassiopeiæ. | ..... | Id. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, Altitude a Azimuth |
|---|---|---|---|---|---|---|
| 1865. | h m s | | | | | |
| Aug. 3 | 12 25 a.m. | Solent (Isle of Wight). | =1st mag.* ..... | White ..... | 1 second ..... | From γ Pegas Piscium. |
| 3 | 12 34 a.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·7 second ... | From α La halfway to gasi. |
| 3 | 12 40 a.m. | Ibid ..... | =2nd mag.* ..... | Yellow ..... | 0·8 second ... | From α Cygni (π, 16) Ly |
| 3 | 12 45 a.m. | Ibid ..... | =3rd mag.* ..... | Dull ..... | ..... | From ½ (κ, Q phei to ½ Ursæ Mino |
| 3 | 12 50 a.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·6 second ... | Appeared at ½ Cygni; ¾ of the w α Lyræ. |
| 3 | 12 55 a.m. | Ibid ..... | =1st mag.* ..... | White ..... | 0·8 second ... | From ε to L C lopardi. |
| 3 | 12 58 a.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·4 second ... | From β Cassio to ½ (ε Ce ρ Cassiopeiæ |
| 3 | 1 35 a.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·5 second ... | From BAC 72 ξ Cephei. |
| 3 | 1 43 a.m. | English Channel (near Isle of Wight). | =3rd mag.* ..... | Yellow ..... | 1·1 second ... | To π Ursæ Maj halfway fro Custodis. |
| 25 | 8 57 p.m. | Weston-super-Mare. | =3rd mag.* ..... | Blue ..... | 0·5 second ... | α= From 302° – to 306 – |
| 25 | 10 2 p.m. | Ibid ..... | =1st mag.* ..... | Yellow ..... | 0·75 second ... | From 335° – to 332 – |
| 30 | 7 46 p.m. | Primrose Hill ... | =1st mag.* ..... | Ruddy ..... | ..... | Commenced Aurigæ. |
| Sept. 3 | 9 35 p.m. | Hawkhurst (Kent). | =3rd mag.* ..... | White ..... | 0·8 second ... | Disappeared Draconis; ¾ of the way β Draconis. |
| 6 | 0 0 a.m. | Halton, near Hastings. | Appeared much brighter than the planets. | White ..... | ..... | From the Do to the S.W. rizon. |
| 6 | 10 0 p.m. | Royal Observatory, Greenwich. | =1st mag.* ..... | Bluish white .. | ..... | From a point 5° above ζ point about much benea Ursæ Majoris |
| 7 | 10 35 p.m. | Hawkhurst (Kent). | =3rd mag.* ..... | White ..... | 0·5 second ... | From ξ to ¼ ( Draconis. |
| 7 | 10 45 p.m. | Ibid ..... | =2nd mag.* ..... | Orange yellow | 0·5 second ... | From ½ (ε Ho rum, α Lacer to ½ (η, π gasi. |
| 7 | 11 20 p.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·5 second ... | From α Lyræ, h way to ζ H culis. |
| 14 | 9 24 30 p.m. | Royal Observatory, Greenwich. | =3rd mag.* ..... | White ..... | Very rapid ... | Disappeared 2° low δ Persei. |

| rance; Train, if any, nd its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| ..... | ..... | ..... | ..... | A. S. Herschel. |
| n or sparks ..... | ..... | ..... | ..... | Id. |
| streak for 2 seconds ..... | ..... | ..... | ..... | Id. |
| in or sparks ..... | ..... | ..... | ..... | Id. |
| in or sparks ..... | ..... | ..... | ..... | Id. |
| ain or sparks ..... | ..... | ..... | ..... | Id. |
| a streak for 1 second | ..... | ..... | ..... | Id. |
| train or sparks ..... | ..... | Beams of Aurora in the north, reaching up to Polaris. Very strong auroral light in that direction. | ..... | Id. |
| train or sparks ..... | ..... | Auroral light still strong in the north. | ..... | Id. |
| train or sparks ..... | ..... | ..... | ..... | W. H. Wood. |
| train or sparks ..... | ..... | ..... | ..... | Id. |
| ken train of sparks ... | 10° ..... | Directed from $\alpha$ Cygni... | ..... | T. Crumplen. |
| stinct nucleus ..... | ..... | Fine clear night; full moon. | ..... | A. S. Herschel. |
| bular; like the moon; isappeared quickly. | ..... | Fell vertically down ... | A momentary view of the meteor behind trees. | Communicated by A. S. Herschel. |
| ..... | ..... | Inclined ..... | ..... | F. Trapaud; Ernest Jones. |
| train or sparks ..... | ..... | ..... | ..... | A. S. Herschel. |
| train or sparks ..... | ..... | ..... | ..... | Id. |
| train or sparks ..... | ..... | ..... | Three meteors in one hour: clear sky; moon nearly full; one observer. | Id. |
| ..... | 6° ..... | Directed from Polaris... | ..... | Arthur Harding. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, Altitude a Azimuth |
|---|---|---|---|---|---|---|
| 1865. | h m s | | | | | |
| Sept. 14 | 9 30 p.m. | Weston-super-Mare. | =1st mag.* ..... | Blue ..... | 1 second ..... | $\alpha$= From 331° to 325 |
| 14 | 9 45 p.m. | R. Observatory, Greenwich. | =2nd mag.* ..... | Blue ..... | 1 second ..... | Commenced of $\gamma$ Bootis |
| 14 | 10 0 p.m. | Weston-super-Mare. | =2nd mag.* ..... | Blue ..... | 0·5 second ... | $\alpha$= From 335° to 340 |
| 15 | 9 56 p.m. | Primrose Hill ... | =Capella..... | Bluish white... | 0·8 second ... | From $\nu$ Pisci 1½° belo Pegasi. |
| 15 | 11 15 p.m. | Hawkhurst (Kent). | =2nd mag.* ..... | White ..... | 0·4 second ... | Disappeared Herculis. |
| 16 | 1 25 a.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·5 second ... | From T Cep 35 Draconi |
| 16 | 1 37 a.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·5 second ... | From $\epsilon$ to 1 $\lambda$ Ursæ Ma |
| 16 | 2 2 a.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·8 second ... | From ¼ (Pola Camelopard $\lambda$ Draconis. |
| 16 | 2 6 a.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·7 second ... | From $b$ to L lopardi. |
| 16 | 2 8 a.m. | Ibid ..... | =Sirius ..... | White ..... | 0·6 second ... | Disappeared way between $f$ Monocerot course halfw from $\nu$ Orion |
| 16 | 2 19 a.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·6 second ... | Disappeared Ceti; course way from $\gamma$ |
| 16 | 2 22 a.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·7 second ... | From $e$ Custo $\iota$ Cephei. |
| 16 | 2 28 a.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·6 second ... | From $\zeta$ to ¼ ( Cassiopeiæ. |
| 16 | 2 29 a.m. | Ibid ..... | =3rd mag.* ..... | Red ..... | 2·5 seconds ... | From $\chi$ Pers ¼ ($b$ Lync Camelopard |
| 16 | 2 32 a.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0 5 second ... | From $\rho$ Persei Triangulæ, onwards ha far again. |
| 16 | 9 0 p.m. | Hardwick ..... | Larger than a 1st mag.*. | ..... | ..... | Crossed the G in a line fro Cephei towa Andromedæ |
| 16 | Instantly afterwards. | Ibid ..... | =3rd mag.* ..... | ..... | ..... | From $\gamma$ Pega $\psi$ and $\chi$ cium. |
| 16 | 9 10 30 p.m. | Ibid ..... | =2nd mag.*, diminishing. | ..... | ..... | Near $\alpha$ Pegasi. |
| 16 | 10 20 p.m. | Ibid ..... | First seen as 1st mag.*, soon increasing to greatest splendour of ♀, but after its change of colour, proceeding more feebly, as though burnt out. | Fine yellow, at about ⅘ds of its course changing to, I think, a pinkish hue. | Slow course of 3 seconds, or perhaps 4 seconds. | From Gloria dcrici to ne Andromedæ. |

| arance; Train, if any, and its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| ..... | ..... | ..... | ..... | W. H. Wood. |
| ..... | 8° ..... | Fell perpendicularly ... | ..... | Arthur Harding. |
| ..... | ..... | ..... | ..... | W. H. Wood. |
| a train of 15°; half a ead, fading from the ds to the centre. | ..... | ..... | Train vivid blue; more intense as it faded away. | T. Crumplen. |
| rain or sparks ..... | 5°..... | Directed from Polaris ... | ..... | A. S. Herschel. |
| rain or sparks ..... | ..... | ..... | ..... | Id. |
| a streak for 2 seconds | ..... | ..... | Radiant, $\beta$ Aurigæ ..... | Id. |
| train or sparks ..... | ..... | ..... | A bright meteor. Radiant, Polaris. | Id. |
| a streak for 2 seconds | ..... | ..... | Radiant, $\beta$ Aurigæ ..... | Id. |
| a streak for 6 seconds, here it disappeared ith a flash. | ..... | ..... | Radiant, $\nu$ Orionis ..... | Id. |
| a streak for 1 second | ..... | ..... | Radiant, $\beta$ Aurigæ ..... | Id. |
| a streak for half a econd. | ..... | ..... | Radiant, $\beta$ Aurigæ ..... | Id. |
| ..... | ..... | ..... | ..... | Id. |
| istinct nucleus, sur- ounded by red sparks; ied out gradually. | ..... | ..... | Radiant, in the W. ..... | Id. |
| a streak for 2 seconds | ..... | ..... | Radiant, $\beta$ Aurigæ ..... | Id. |
| ..... | 10° or 15°. | ..... | Very ill seen, by oblique vision only. | T. W. Webb. |
| ..... | ..... | ..... | ..... | Id. |
| ..... | ..... | W. to E. ..... | Very ill seen ..... | Id. |
| tle or no train, but ear-shaped (being larger than ♀), and sparkling at its narrow end when it changed colour. | ..... | Path a little curved; convex, I believe, to Polaris. | A superb effect, causing me to turn right round from eyepiece of telescope. | Id. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, or Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1865. Sept. | h m s | | | | | |
| 17 | 10 12 p.m. | Primrose Hill ... | =2½ mag.* ..... | White ..... | 0·5 second ... | From ε Herculis to E Herculis. |
| 17 | 10 26 p.m. | Ibid ..... | =1½ mag.* ..... | White ..... | 0·4 second ... | Commenced 2½° below β Aquarii. |
| 17 | 11 2 30 p.m. | Ibid ..... | =3rd mag.* ..... | ..... | ..... | From ζ Cassiopeiæ to 1° beyond Camelopard. |
| 17 | 11 8 p.m. | Ibid ..... | =3rd mag.* ..... | ..... | ..... | From γ Andromedæ to α Persei. |
| 17 | 11 16 p.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·7 second ... | From Pleiades to (ζ, η) Aurigæ. |
| 17 | 11 21 p.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·4 second ... | From β to θ Andromedæ. |
| 17 | 11 36 p.m. | Ibid ..... | =3rd mag.* ..... | Bluish ..... | 0·5 second ... | From α Cassiopeiæ to γ Andromedæ. |
| 18 | 1 8 a.m. | Hawkhurst (Kent). | =2nd mag.* ..... | White ..... | 0·4 second ... | Commenced at ε Herculis; course halfway to σ Herculis. |
| 18 | 1 11 a.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·5 second ... | Commenced at Cassiopeiæ. |
| 18 | 1 15 a.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·5 second ... | Close to β Draconis |
| 18 | 1 22 a.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·5 second ... | Disappeared at (α Andromedæ β Pegasi); halfway from π Andromedæ. |
| 18 | 1 30 a.m. | Ibid ..... | =3rd mag.* ..... | Orange yellow | 1·5 second ... | Disappeared at Arietis; course three-quarters of the way from γ Ceti. |
| 18 | 1 38 a.m. | Ibid ..... | =3rd mag.* ..... | Red ..... | 1·5 second ... | From 2° under Ceti to E Piscium. |
| 18 | 1 46 a.m. | Ibid ..... | =3rd mag.* ..... | Bright white... | 0·6 second ... | From ε Custodis to π Cephei. |
| 18 | 1 50 a.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·6 second ... | From ε to f Ursæ Majoris. |
| 18 | 2 1 a.m. | Ibid ..... | =3rd mag.* ..... | Red ..... | 0·9 second ... | Disappeared at Tauri; course halfway from ε Arietis. |
| 18 | 10 10 p.m. | Tooting, Surrey.. | ..... | ..... | ..... | From γ Pegasi nearly across ε Pegasi, passing about half a degree below the star. |
| 18 | 11 1 p.m. | Hawkhurst (Kent). | =3rd mag.* ..... | White ..... | 0·5 second ... | Commenced at Draconis. |
| 18 | 11 6 p.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·3 second ... | From μ Cygni to Pegasi. |

| earance; Train, if any, and its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| t a short train of 1½°... | ..... | On a line produced to between B and C Herculis. | Sky very clear: several others seen during the evening. | T. Crumplen. |
| e-shaped; left a slight rain. | 5°..... | Directed from γ Aquarii | ..... | Id. |
| ..... | ..... | ..... | ..... | Id. |
| ..... | ..... | ..... | Radiant, in Cygnus..... | Id. |
| t a short train of 3° ... | ..... | ..... | ..... | Id. |
| ..... | ..... | ..... | ..... | Id. |
| ft a short train of 2° ... | ..... | ..... | ..... | Id. |
| o train or sparks ..... | ..... | ..... | Radiant, E G; branch in Cygnus. | A. S. Herschel. |
| o train or sparks ..... | 4°; very short path. | Directed from α Cassiopeiæ. | Radiant, in Cassiopeia .. | Id. |
| o train or sparks ..... | Nearly stationary. | ..... | Radiant, E G; branch in Cygnus. | Id. |
| o train or sparks ..... | ..... | ..... | Radiant, in Cassiopeia .. | Id. |
| ft a streak for ½ a second | ..... | From Radiant, T in Cetus. | ..... | Id. |
| ucleus surrounded by red sparks. | ..... | From Radiant, T in Cetus. | ..... | Id. |
| ..... | ..... | Radiant, β Aurigæ ..... | ..... | Id. |
| ..... | ..... | Radiant, in Cassiopeia ... | ..... | Id. |
| ucleus surrounded with red sparks. | ..... | From Radiant, in the W. | Twenty-four meteors in one hour: clear sky; no moon; one observer. | Id. |
| Appeared brighter and larger by far than Venus at her brightest. | ..... | About one-sixth of the arch of the sky. | Left an exceedingly luminous, almost dazzling train. | H. W. Jackson. |
| ..... | 5°..... | Directed from α Aurigæ. Radiant, β Aurigæ. | Note.—That χ Draconis is as bright and a little brighter than η Cephei to-night. | A. S. Herschel. |
| Nearly stationary ..... | ..... | Radiant, α Cygni..... | ..... | Id. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, o Altitude an Azimuth. |
|---|---|---|---|---|---|---|
| 1865. Sept. 18 | h m s 11 17 p.m. | Hawkhurst (Kent). | =2nd mag.* ..... | White ..... | 1 second ... | From $\alpha$ Lacer $\frac{2}{3}$ ($\delta$ Lacertæ Cygni). |
| 18 | 11 25 p.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·8 second ... | From $\mu$ Androm to $\psi$ Pegasi. |
| 18 | 11 30 p.m. | Ibid ..... | =1st mag.*..... | Yellow ..... | 1·4 second ... | From $\alpha$ Piscium $\delta$ Ceti, and as far again. |
| 18 | 11 36 p.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 1 second ..... | From $\frac{1}{2}$ ($r$, $s$) scium, halfw to $\epsilon$ Aquarii. |
| 18 | 11 53 p.m. | Ibid ..... | =2nd mag * ..... | White ..... | 0·5 second ... | From $\pi_2$ to $\gamma$ Cy |
| 19 | 8 15 30 p.m. | Lothbury, London. | One-fifth apparent size of the moon. | ..... | ..... | Disappeared ab 35° altitude. |
| 19 | 8 21 p.m. | Eton Street, Primrose Hill. | =4th mag.* ..... | White ..... | 0·3 second ... | From $\gamma$ Andromed 3° on towa 1° below $\beta$ A dromedæ. |
| 19 | 9 24 p.m. | Weston-super-Mare. | =2nd mag.* ..... | Blue ..... | 0·5 second ... | $\alpha$ = From 335° − 1° to 340° − 3. |
| 19 | 9 26 p.m. | Ibid ..... | =3rd mag.* ..... | Blue ..... | 0·5 second ... | From 123° + 6 to 113 + 56 |
| 19 | 9 28 p.m. | Royal Observatory, Greenwich. | =1st mag.*..... | Blue ..... | 2 seconds..... | From a point abo 2° below $\alpha$ Dr conis towards Ursæ Majoris. |
| 19 | 9 40 p.m. | Weston-super-Mare. | =2nd mag.* ..... | Blue ..... | 0·5 second ... | $\alpha$ = From 260° + 5 to 271 + 2 |
| 19 | 9 50 p.m. | Ibid ..... | =3rd mag.* ..... | Blue ..... | 0·5 second ... | From 305° + 11 to 300 − 2 |
| 19 | 10 0 p.m. | Ibid ..... | =1st mag.* ..... | Blue ..... ... | 0·5 second ... | From 42° + 4 to 26 + 34 |
| 19 | 10 2 p.m. | Ibid ..... | =2nd mag.* ..... | Blue ..... | 0·5 second ... | From 335° − 1 to 329 − 8. |
| 19 | 10 15 p.m. | Ibid ..... | =1st mag.* ..... | Yellow ..... | 1 second ..... | From 90° + 6 to 149 + 66. |
| 19 | 10 17 p.m. | Ibid ..... | =3rd mag.* ..... | Blue ..... | 0·5 second ... | From 322° + 7 to 318 − 7. |
| 20 | 5 0 a.m. (local time.) | Paraclet, Aube, France. | Large and bri'liant | ..... | Rapid ..... | From N. to S. ..... |

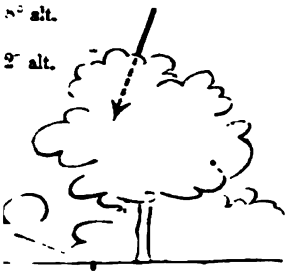
| arance; Train, if any, and its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| ıtest at the middle of course; left a streak half a second. | ..... | Radiant, $\alpha$ Cygni..... | ..... | A. S. Herschel. |
| a streak for 2 secs.... | ..... | ..... | ..... | Id. |
| ıtest at the middle of course. No train or arks. | ..... | Radiant T, in Cetus..... | ..... | Id. |
| rain or sparks ..... | ..... | Radiant T, in Cetus..... | ..... | Id. |
| a streak for 2 conds. | ..... | Radiant, $\nu$ Orionis ..... | Twenty-two meteors in one hour: clear sky; no moon; one observer. | Id. |
| st into numerous parks, like the explosion of gunpowder. eft a long train of ight which was visible or several seconds. | ..... | Passed horizontally from N.N.E. to N.N.W. | ..... | Communicated by T. Crumplen. |
| ..... | 3° ..... | ..... | Large meteor at 8.15 p.m. Light seen at Eton Street. | T. Crumplen. |
| ..... | ..... | ..... | ..... | W. H. Wood. |
| ..... | ..... | ..... | ..... | Id. |
| ..... | 12° ..... | Nearly horizontal ..... | ..... | Arthur Harding. |
| ..... | ..... | ..... | ..... | W. H. Wood. |
| ..... | ..... | ..... | ..... | Id. |
| ..... | ..... | ..... | ..... | Id. |
| ..... | ..... | ..... | ..... | Id. |
| ..... | ..... | ..... | Tail 10°; lasted 2 secs. | Id. |
| ..... | ..... | ..... | ..... | Id. |
| uminous body, dividing itself into two large stars, which afterwards burst into sparks. | ..... | N. to S. ..... | Four or five minutes afterwards a sound like a clap of thunder was heard which lasted five or six minutes. The sky was slightly overcast, but not sufficiently to hide the stars. | Les Mondes, 1st ser. vol. ix. p. 400. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, or Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1865. Sept. | h m s | | | | | |
| 20 | 7 39 p.m. | Eton Street, Primrose Hill. | =Arcturus ..... | White ..... | 0·6 second ... | From midway between λ and Draconis to above δ Majoris. |
| 20 | 8 12 p.m. | Hawkhurst (Kent). | =3rd mag.* ..... | White ..... | 0·6 second ... | From τ Herculis to ε Coronæ. |
| 20 | 8 20 p.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·7 second ... | From A Draconis to τ Ursæ Minoris. |
| 20 | 8 22 p.m. | Ibid ..... | =2nd mag.* ..... | Bright white... | 1·5 second; very slow motion. | From $X_1$ Herculis to ½ (α Herculis to ε Ophiuchi). |
| 20 | 9 43 p.m. | Royal Observatory, Greenwich. | =1st mag.*..... | Bluish white... | Very rapid ... | Fell vertically from a point about 3° E. of α Aquilæ. |
| 20 | 9 44 p.m. | Ibid ..... | =3rd mag.* ..... | Blue ..... | ½ second ..... | From the direction of θ Coronæ Borealis to a point between ε and ζ Bootis. |
| 21 | 8 30 p.m. | Weston-super-Mare. | =2nd mag.* ..... | Blue ..... | 1 second ..... | α = ζ = From 197° + 45° to 211 + 19. |
| 22 | 7 57 p.m. | Dipley, Hampshire. | Larger than Jupiter | Vivid white ... | ..... | Path may be taken as similar to that of one on September 24th. |
| 22 | 9 30 p.m. | Royal Observatory, Greenwich. | =2nd mag.* ..... | Blue ..... | 1 second +... | From a point about 3° E. of θ Pegasi to a point 2° above ε Pegasi. |
| 23 | 10 15 p.m. | Weston-super-Mare. | =3rd mag.* ..... | Blue ..... | 1 second ..... | α = ζ = From 160° + 68° to 158 + 54. |
| 24 | 7 48 p.m. | Hawkhurst (Kent). | =3rd mag.* ..... | ..... | 0·9 second ... | Disappeared at Cassiopeiæ. Course ¾ of the way from α Trianguli. |
| 24 | 7 48 + p.m. | Ramsgate (Kent) | As bright as Jupiter | White or bluish | 3·5 seconds ... | From a point near α Aquarii below Aquila, across the Milky Way, to a point near τ Ophiuchi; disappearing a few degrees above Jupiter. |
| 24 | 7 48 45 p.m. | Royal Observatory, Greenwich. | Larger and brighter than Jupiter. | Bluish white.. | 2–3 seconds... | First seen near ψ Aquarii, disappeared near ε Capricorni. |
| 24 | 7 50± p.m. | Hawkhurst (Kent). | = Sirius ..... | White ..... | 4 seconds..... | From β Piscium to k Aquilæ. |
| 24 | 7 55 p.m. | Ibid ..... | =3rd mag.* ..... | ..... | 0·8 second ... | From ε to ¼ (λ, ρ Honorum. |

| arance; Train, if any, and its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| a train of 1° | | | Kite-shaped, very brilliant. | T. Crumplen. |
| rain or sparks | | Radiant, in Cassiopeia | | A. S. Herschel. |
| rain or sparks | | Radiant, in Cygnus | | Id. |
| eus a stellar point; train or sparks. | | | A singular meteor | Id. |
| | 8° | Perpendicular | | Arthur Harding. |
| | 10° | Inclined | | Id. |
| | | | | W. H. Wood. |
| | Very brilliant. | | The meteor finally exploded into a number of fragments. | Mrs. Crumplen. |
| train | 15° | | | Arthur Harding. |
| | | | | W. H. Wood. |
| train or sparks | | Radiant, in Cassiopeia | | A. S. Herschel. |
| arly resembling the planet Jupiter, followed by a train of light about 1° in length. | | | Identical with the next (Greenwich, 7h 48m 45s p.m.). | S. Gorton. |
| int train | 30°+ | Path parallel to the Ecliptic. | Very bright meteor (see Appendix I.). | W. C. Nash. |
| llowed by a train of red sparks 3° long, and disappearing gradually, leaving a faint streak on its whole course for ½ a second. | 40° | From Radiant, T in Pisces. | Identical with the preceding (Greenwich, 7h 48m 45s p.m.). | A. S. Herschel. |
| o train or sparks | | Radiant, in Andromeda | | Id. |

UNIVERSITY OF CALIFORNIA

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, or Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1865. Sept. 24 | h m 7 58 p.m. | Hawkhurst (Kent). | =2nd mag.* ..... | White ..... | 0·7 second ... | From $\varrho$ to $\tau$ Piscium and onwards far again. |
| 24 | 8 5 p.m. | Ibid ..... | =3rd mag.* ..... | Yellow ..... | 0·8 second ... | From $\eta$ Pegasi to $\frac{1}{2}$ ($\beta$ Pegasi, Andromedæ. |
| 24 | 8 25 p.m. | Frome, Somersetshire. | Large and brilliant ..... | ..... | ..... | First appeared at Draconis; disappeared at a point in R.A. 16h, Decl. 75°. |
| 24 | 8 30 p.m. | Royal Observatory, Greenwich. | Three times as great as Jupiter. | Flame-colour.. | 5 seconds..... | From the direction of the centre of Bootis (above Arcturus) towards N.; then appeared below Ursa Major. |
| 24 | 8 30 p.m | Dipley, Winchfield, Hants. | Three times as bright as Jupiter. | Pale blue..... | 1·5 second ... | Passed 2½° below $\alpha$ Coronæ, and 16° onwards, along a line produced 3° above Cor Caroli. |
| 24 | 8 30 p.m. | Twelve miles south of Manchester. | As bright as Jupiter. Small clearly defined disk. | White; very luminous. | Slow motion; 2 or 3 secs. | In the southern sky, about S.W. to S.S.W.; from altitude barely 20°; fell about 6° |
| 24 | 9 5 p.m. | Hawkhurst (Kent). | =1st mag.* ..... | White ..... | 1·4 second ... | From 1° S. of Andromedæ to 2° S. of $\zeta$ Pegasi |
| 24 | 9 19 p.m. | Ibid ..... | =3rd mag.* ..... | Bright yellow | 1 second ..... | From $\eta$ to $\frac{1}{2}$ ($\epsilon$, $\lambda$ Persei. |
| 24 | 9 20 p.m. | Ibid..... | =3rd mag.* ..... | White ..... | 1 second ..... | From $\epsilon$ Lacertæ to ($\epsilon$, $\zeta$) Cygni. |
| 24 | 9 26 p.m. | Ibid ..... | =3rd mag.* ..... | Yellow ..... | 0·7 second ... | Commenced at Pegasi. |

| ...rance; Train, if any, ...nd its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| ...in or sparks ..... | Short path.. | Radiant T, in Pisces ... | ..... | A. S. Herschel. |
| ...in or sparks ..... | ..... | ..... | ..... | Id. |
| ...t ball of fire, after-...ds breaking up in a ...t ful manner, and ...ing large sparks in ...train till it appeared ...urn itself out. | ..... | ..... | A crackling noise, resembling that of a rocket in the air, could be distinctly heard. | 'The Times.' |
| ...train, many sparks. | ..... | Curved..... | Path not very accurately observed. | Thomas Wright. |
| ...ular; threw off a ...mber of red and ...ange sparks. Train ...oken into sparks; en-...red 1 second. | 15° or 16°.. | ..... | Not seen quite at commencement. Path well observed; nucleus burst into fragments; no noise heard. | T. Crumplen. |
| | | | | |
| ...° alt. | | | | |
| ...° alt. | | Fell almost perpendicularly. | Many shooting-stars in a few minutes. | Communicated by R. P. Greg. |
|  South. | | | | |
| ...a streak on its whole ...urse for 10 seconds, ...hich faded from the ...ds towards the centre. | ..... | Radiant, $\beta$ Aurigæ ..... | ..... | A. S. Herschel. |
| ...htness gradually in-...eased, and disappeared ...maximum brightness. | ..... | Radiant A, in Cassiopeia ..... | ..... | Id. |
| ...train or sparks ..... | ..... | ..... | ..... | Id. |
| ...train or sparks ..... | ..... | From Radiant $R_{11}$ in Pegasus. | ..... | Id. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, or Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1865. Sept. 24 | h m 9 29 p.m. | Hawkhurst (Kent). | =2nd mag.* ..... | Yellow ..... | 1·2 second ... | From α Arietis of the way Algol. |
| 24 | 10 55 p.m. | Ibid ..... | Brighter than a 1st mag.* | Bluish white.. | 2·5 seconds ... | From α Persei c Camelopar and onwards far again. |
| 24 | 11 15 p.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·8 second ... | From ½ (ρ H conis, θ Cep to ε Cygni. |
| 25 | 7 25 p.m. | Winchfield, Hampshire. | =2nd mag.* ..... | White ..... | ..... | From Polaris to Ursæ Minoris |
| 25 | 8 53 p.m. | Winchfield Railway Station. | =Arcturus ..... | White ..... | 0·4 second ... | From O Cam pardi to θ Boo |
| 25 | 8 12 p.m. | Wolverton, Stacey Hill. | Appeared as large as a rocket. | ..... | Slow motion; 3 seconds. | Started about north. |
| 25 | 8 12 p.m. | Hawkhurst (Kent). | =2nd mag.* ..... | White ..... | 2·2 seconds ... | From β Cassiop to γ Pegasi. |
| 25 | 8 28 p.m. | Ibid ..... | =1st mag.*..... | White ..... | 0·8 second ... | From P to N Cam lopardi. |
| 25 | 8 34 p.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·7 second ... | Disappeared at Cygni; cou halfway from Pegasi. |
| 25 | 8 56 p.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·6 second ... | From Polaris t (ε Ursæ Mino u Cephei). |
| 25 | 9 20 p.m. | Weston-super-Mare. | Two-thirds of moon | Violet ..... | 4 seconds..... | α = From 195° + 5 to 295 |
| 25 | 10 50 p.m. | Hawkhurst (Kent). | =2nd mag.* ..... | White ..... | 0·6 second ... | From p Cam pardi to π U Majoris. |
| 25 | 10 59 p.m. | Ibid ..... | =2nd mag.* ..... | Bright white.. | 1·3 second ... | From ½ (α Vu culæ, α Sag to Altair. |
| 25 | 11 0 p.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·7 second ... | From ε Pegasi Delphini. |
| 25 | 11 17 p.m. | Eton Street, Primrose Hill. | =1st mag.* ..... | White ..... | 0·4 second ... | From η Cyg midway bet Delphinus Aquilæ. |
| 26 | 8 55 p.m. | Kilvington, Thirsk (Yorkshire). | Large and very brilliant. | ..... | Very slow motion. | First appeared to the hor Passed bet β and γ Ar medæ, and n reached α Aq close to star it d peared. |

| ırance; Train, if any, nd its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| tness increased gra-lly, disappeared at ntest brightness. | ..... | Radiant T, in Pisces ... | In one hour seventeen meteors: clear sky; no moon; one observer. | A. S. Herschel. |
| in or sparks ..... | ..... | Radiant T, in Pisces ... | ..... | Id. |
| in or sparks ..... | ..... | Radiant, Polaris ..... | ..... | Id. |
| ..... | 3° ..... | ..... | Well-observed by prominent stars. Shooting-stars very frequent. Seven radiant from Polaris; and several 5° below Delphinus. | T. Crumplen. |
| t train, equal to length path, faded gradually. | ..... | ..... | Fine meteor; train faded from ends to centre. | Id. |
| an exceedingly bril-nt train for 2 seconds a distinctly crimson ade. | ..... | ..... | Numerous shooting-stars during the evening. | 'The Times.' |
| a streak on its ble course for half a cond. | ..... | Radiant, Polaris ..... | ..... | A. S. Herschel. |
| a streak for 2 seconds, ich faded from the ds towards the centre. | ..... | Radiant, $\beta$ Aurigæ ..... | ..... | Id. |
| ..... | ..... | Radiant R (branch in Pegasus). | ..... | Id. |
| a streak for 2 seconds | ..... | ..... | ..... | Id. |
| ..... | ..... | ..... | ..... | W. H. Wood. |
| train or sparks ..... | ..... | Radiant, in Cassiopeia... | ..... | A. S. Herschel. |
| ves a small bright nt. | ..... | Radiant, in N.W. ..... | ..... | Id. |
| ain or sparks ..... | ..... | Radiant R (branch in Pegasus). | ..... | Id. |
| equal to length of . very luminous, ured 1 second. | ..... | ..... | ..... | T. Crumplen. |
| t increased rapidly rightness, afterwards ained constant for e time, and at length reased very gradually brilliancy; left a train, y 60° in length. | ..... | ..... | ..... | W. Kingsley. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, or Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1865. Sept. 26 | h m s 8 55 p.m. | Hawkhurst (Kent) | Brighter than α Lyræ. | White ..... | 3½ seconds ... | From a point near γ Lyncis to a point between ε and δ Ursæ Majoris. (Approximate position taken the next evening.) |
| 26 | 9 0 p.m. | Blackheath ..... | = 1st mag.* ..... | White ..... | 1 second ..... | From a point near φ Aquarii, passed between ζ and η Aquarii. |
| 26 | 9 18 p.m. | Ibid ..... | = Jupiter..... | Bluish white .. | 3 seconds..... | Directed from Polaris to a point just below ζ Ursæ Majoris. |
| 26 | 9 19 p.m. | Eastbourne (Sussex). | Brighter than Jupiter is at its brightest. | Greyish white, then emerald green. | 3 to 4 secs. ... | In Bootes; from R. A. 14ʰ 25ᵐ Decl. N. 25°, to R. A. 14ʰ 20ᵐ Decl. N. 15°. |
| 26 | 9 20 p.m. | Weston-super-Mare. | ¼, apparent diameter of the moon. | Violet colour. | 4 seconds..... | α = δ = From 195° + 53° to 295 0 |
| 26 | 9 21 p.m. | Blackheath ..... | Brighter than Jupiter. | Blue; very brilliant. | 3 seconds..... | From a point about 3° E. of ε Herculis, passed to the right of Herculis, and disappeared in the neighbourhood of ι and Ophiuchi. |
| 26 | 9 35 p.m. | Lamberhurst, Sussex. | = 2nd mag.* ..... | White ..... | 0·4 second ... | From ½ (β, μ) to Andromedæ. |
| 26 | 9 41 p.m. | Ibid ..... | = 1st mag.* ..... | White ..... | 1 second .. ... | From α Equulei to β Aquari; and onwards about as far, continued. |
| 26 | 9 54 p.m. | Royal Observatory, Greenwich. | = 2nd mag.* ..... | White ..... | 1 second ..... | Directed from Draconis to Herculis. |
| 26 | 10 41 p.m. | Hawkhurst (Kent). | = 3rd mag.* ..... | Yellow..... | 0·8 second ... | From λ to r Piscium. |
| 26 | 11 55 p.m. | Eton Street, Primrose Hill. | = 1·2 mag.* ..... | Pale blue ..... | 0·5 second ... | From η Cygni to between β and Lyræ. |
| 27 | 9 35 p.m. | Ibid ..... | = 4th mag.* ..... | ..... | 0·5 second ... | From α Persei to Muscæ. |
| 27 | 9 35 30 p.m. | Royal Observatory, Greenwich. | = 3rd mag.*..... | White ..... | Very rapid motion. | Directed from Aquilæ to a point a little W. of and β Capricorni |

| ırance; Train, if any, ınd its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| ıt no alteration in its ht; then gradually ınished until it dis- ıeared; left a streak its whole course for ıeconds. | | | | Communicated by A. S. Herschel. |
| rain | 10° | Inclined | | Arthur Harding. |
| rain | 25° | Inclined | | Id. |
| ıppeared almost, but ıt quite as suddenly ı it appeared. | | | Sky free from clouds. (Identical with the preceding meteor.) | G. F. Chambers. |
| ıdually increased, and hen again gradually de- reased, as if by the ffect of distance; a long rain attended the me- eor. | | | Illuminated the surrounding country with a light as intense as that of full moon. (Identical with the preceding: see Appendix I.) | Communicated by W. H. Wood. |
| | 30° | Inclined | | Arthur Harding. |
| train or sparks | | | | A. S. Herschel. |
| train or sparks | | | | Id. |
| train | 15° | Nearly perpendicular | | Arthur Harding. |
| train or sparks | | | | A. S. Herschel. |
| | 5° | | | T. Crumplen. |
| | 3° | | Several shooting-stars to-night. Radiant, near α Persei. | Id. |
| ) train | 12° | Inclined | | Arthur Harding. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, or Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1865. | h m | | | | | |
| Sept.28 | 1 12 a.m. | Hawkhurst (Kent). | =3rd mag.* ..... | Yellow ..... | 0·4 second ... | From ½ (g, k) Ly to ε Ursæ joris. |
| 28 | 1 18 a.m. | Ibid ..... | =2nd mag.* ..... | Bright white... | 0·4 second ... | From θ to η Ce and onwards far again. |
| 28 | 1 19 a.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·4 second ... | From ε, half to θ Ursæ joris. |
| 28 | 1 22 a.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·4 second ... | From θ Andro to ½ (α An medæ, β Peg |
| 28 | 1 26 a.m. | Ibid ..... | =3rd mag.* ..... | Yellow ..... | 0·7 second ... | From ι to ν rigæ. |
| 28 | 1 34 a.m. | Ibid ..... | =2nd mag.* ..... | Bright white, then red. | 2·2 seconds ... | From ι Dra halfway to Ursæ Majo |
| 28 | 1 35 a.m. | Ibid ..... | =3rd mag.* ..... | Dull ..... | ..... | From ½ (ε, α) U Majoris to ε L conis. |
| 28 | 1 37 a.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·7 second ... | From η to φ Pe |
| 28 | 1 45 a.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·5 second ... | Appeared at ν Per |
| 28 | 10 4 p.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·6 second ... | Commenced at Draconis. |
| 28 | 10 20 p.m. | Ibid ..... | =3rd mag.* ..... | Yellow ..... | 0·7 second ... | Commenced at Camelopardi. |
| 28 | 10 42 p.m. | Ibid ..... | =2nd mag.* ..... | Yellow ..... | 1·2 second ... | From 20 Custodis ½ (K, P) Cam lopardi. |
| 28 | 10 44 p.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 1·4 second ... | From ½ (ε, ζ) Ur Minoris to (P, Q) Camel pardi. |
| 28 | 11 5 p.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 1·2 second ... | From ½ (β, Cephei to Cygni. |
| 28 | 11 11 p.m. | Royal Observatory, Greenwich. | =3rd mag.* ..... | Bluish white... | Less than 1 sec. | From the direct of ζ Cygni to point near ζ quilæ. |
| 28 | 11 22 p.m. | Ibid ..... | =1st mag.* ..... | Blue ..... | 1 second ..... | From the direct of ε Cygni, fell below and yond α Lyræ. |
| 28 | 11 26 p.m. | Hawkhurst (Kent). | =2nd mag.* ..... | White ..... | 1 second ..... | From χ Cephei t (γ, ξ) Dracon |
| 28 | 11 29 p.m. | Ibid ..... | =3rd mag.* ..... | Yellow ..... | 1·3 second ... | From ½ (π Peg α Lacertæ) t (δ, γ) Cygni. |
| 28 | 11 40 p.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·6 second ... | From ξ to η (C siopeiæ. |
| 28 | 11 46 p.m. | Royal Observatory, Greenwich. | =1st mag.* ..... | Bluish white... | ½ second ..... | Fell vertically i N., from the d rection of Pola disappearing Ursæ Majoris. |

| arance; Train, if any, nd its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| ain or sparks | | From Radiant F, in Auriga. | | A. S. Herschel. |
| ain or sparks | | From a Radiant in Cepheus. | | Id. |
| ain or sparks | | From a Radiant in Cassiopeia. | | Id. |
| ain or sparks | | From a Radiant in Cassiopeia. | | Id. |
| ain or sparks | | From Radiant T, in Cetus. | | Id. |
| ess drawing a train red sparks; grew adually less. | | From Radiant $Q_2$, in Hercules. | | Id. |
| train or sparks | | | | Id. |
| a streak for 1 second | | From Radiant F, in Auriga. | | Id. |
| train or sparks | 5° | Directed from Pleiades. | In 30 minutes thirteen meteors: clear sky; no moon; one observer. | Id. |
| train or sparks | 10° | Directed from $\alpha$ Cygni. | | Id. |
| train or sparks | 8° | Directed towards Capella | Radiant, Polaris | Id. |
| train or sparks | | From Radiant T, between Pisces and Cetus. | | Id. |
| train or sparks | | Radiant, in N.W. | | Id. |
| a streak for 2 seconds | | Radiant F, near $\beta$ Aurigæ. | | Id. |
| train | 10° | | | W. C. Nash. |
| train | 12°+ | | | Id. |
| train or sparks | | Radiant E, in Lacerta | | A. S. Herschel. |
| train or sparks | | Radiant T, in Pisces | | Id. |
| train or sparks | | Radiant R (branch in Andromeda). | | Id. |
| nt train | 12° | Perpendicular | | W. C. Nash. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, or Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1866. Sept. 29 | h m 6 56 p.m. | Royal Observatory, Greenwich. | =1st mag.* ..... | Bluish white... | ½ second ..... | Fell perpendicularly in the W., from the direction of γ Bootis, disappeared at same altitude as Arcturus. |
| 30 | 11 5 p.m. | Hawkhurst (Kent). | =3rd mag.* ..... | Yellow ..... | 0·4 second ... | From μ to α Pegasi. |
| 30 | 11 25 p.m. | Ibid ..... | =3rd mag.* ..... | Yellow ..... | 0·7 second .. | From σ Custodis to P Camelopardi. |
| Oct. 7 | 8 30 p.m. | Royal Observatory, Greenwich. | =2nd mag.* ..... | Blue ..... | ½ second ..... | From the direction of ε Cassiopeiæ towards Polaris. |
| 12 | 9 25 p.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 1 second ..... | Fell vertically from a point just below θ Draconis. |
| 12 | 10 17 p.m. | Weston-super-Mare. | =3rd mag.* ..... | Blue ..... | 1·5 second ... | α = δ = From 28° + 24 to 40 + 28. |
| 12 | 10 18 p.m. | Ibid ..... | =2nd mag.* ..... | Blue ..... | 1 second ..... | From 0° + 15 to 5 + 1. |
| 13 | 6 30 p.m. | Royal Observatory, Greenwich. | =2nd mag.* ..... | Blue ..... | 1½ second ... | Passed across Cassiopeiæ to a point 10° below Polaris. |
| 13 | 8 29 p.m. | Hawkhurst (Kent). | =3rd mag.* ..... | Yellow ..... | 0·6 second ... | Disappeared at (ι, λ) Aquilæ. |
| 13 | 8 30 p.m. | Ibid ..... | =3rd mag.* ..... | Yellow ..... | 0·6 second ... | From 1° E. of Pegasi to Aquarii. |
| 15 | 6 35 p.m. | Weymouth ..... | =2nd mag.* ..... | Blue ..... | 1 second ..... | From a point about 10° below 12 Canum Venaticorum, passed towards Arcturus. |
| 15 | 7 15 p.m. | Ibid ..... | =3rd mag.* ..... | White ..... | Rapid ..... | From μ Andromedæ towards γ Andromedæ. |
| 15 | 8 17 p.m. | Hawkhurst (Kent). | =3rd mag.* ..... | White ..... | 1·3 second ... | Commenced at ½(ι + χ) Piscium; course halfway to γ Pegasi. |
| 16 | 12 50 a.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·5 second ... | Commenced at ι Draconis; course halfway to ζ Ursæ Majoris. |
| 16 | 1 2 a.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·6 second ... | From β Cassiopeiæ to ½(π₁, π₂) Cygni. |
| 16 | About 10 p.m. | Mentone, Alpes Maritimes. | Large meteor ..... | ..... | Travelled at moderate speed. | From a point in Cetus or Pisces, not far from Aries, to a point not far from Altair. |
| 19 | 8 45 p.m. | Weston-super-Mare. | =1st mag.* ..... | Blue ..... | 1 second ..... | α = δ = From 191° + 38 to 182 + 53 |

| arance; Train, if any, and its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| ..... | 8° ..... | Perpendicular ..... | ..... | W. C. Nash. |
| ain or sparks ..... | ..... | From Radiant $R_2$, in Musca. | The previous night overcast. | A. S. Herschel. |
| ain or sparks ..... | ..... | From Radiant R, in Andromeda. | In thirty minutes two meteors: clear sky; moon $\frac{3}{4}$ full. | Id. |
| ..... | 8° ..... | Slightly inclined from horizontal. | ..... | W. C. Nash. |
| f train ..... | 15° ..... | Perpendicular ..... | ..... | Arthur Harding. |
| ..... | ..... | ..... | ..... | W. H. Wood. |
| ... ..... | ..... | ..... | ..... | Id. |
| in ..... | ..... | Curved slightly ..... | The time is correct to one or two minutes. | W. C. Nash. |
| train or sparks ..... | 10° ..... | Directed from ζ Aquilæ | In one hour and thirty minutes, sixteen meteors: sky generally clear; one observer. | A. S. Herschel. |
| train or sparks ..... | ..... | ..... | In the next 30 minutes, four meteors: clear sky; one observer. | Id. |
| train ..... | 10° ..... | Horizontal ..... | No stars visible in the track of the meteor. | Arthur Harding. |
| ..... | 6° ..... | Inclined ..... | ..... | Id. |
| ..... | ..... | ..... | Four meteors in forty-five minutes; clear sky; one observer. | A. S. Herschel. |
| train or sparks ..... | ..... | ..... | ..... | Id. |
| k a streak on its whole ourse for 2 seconds. | ..... | Radiant O ($\nu$ Orionis)... | ..... | Id. |
| llowed by a very distinct train of light, hich remained visible until the meteor disappeared. | 70° or 80°.. | E. to W., following nearly the line of the equator. | ..... | D. A. Freeman, Ast. Reg., Dec., 1865. |
| ..... | ..... | ..... | ..... | W. H. Wood. |

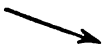
| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1865. | h m | | | | | |
| Oct. 19 | 10 15 p.m. | Royal Observatory, Greenwich. | =2nd mag.* ..... | Bluish white.. | Less than 1 sec. | From direction Cygni, passed cross λ Lyræ. |
| 19 | 10 40 p.m. | Hawkhurst (Kent). | =1st mag.* ..... | White ..... | 1·5 second ... | First appeared ½ (α, ι) Draconis. |
| 19 | 10 56 p.m. | Ibid ..... | =2nd mag.* ..... | Yellow ..... | 0·5 second ... | From r to o Per |
| 20 | 7 1 p.m. | Weymouth ..... | =Jupiter ..... | Bright blue ... | 2 seconds..... | From the direction of Pole passed just be δ Ursæ Min to a point little beyond Lyræ. |
| 20 | 10 3 p.m. | Hawkhurst (Kent). | =3rd mag.* ..... | White ..... | 0·4 second ... | From ½ (ε, ζ) Draconis. |
| 20 | 10 43 p.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·7 second ... | From E, Psc to ½ (δ Ceti, Eridani). |
| 20 | 10 45 p.m. | Ibid ..... | =3rd mag.* ..... | Yellow ..... | 1·2 second ... | Appeared at δ |
| 20 | 10 49 p.m. | Ibid ..... | =3rd mag.* ..... | Yellow ..... | 0·6 second ... | From ε to ε D conis. |
| 20 | 10 56 p.m. | Ibid ..... | =2nd mag.* ..... | Yellow ..... | 0·9 second ... | From ½ (k Lyn e Ursæ Major to ½ (υ, φ) U Majoris. |
| 20 | 10 57 p.m. | Ibid ..... | =3rd mag.* ..... | Yellow ..... | 1 second ..... | From ½ (e Ly p Camelop to k Ursæ M joris. |
| 20 | 10 58 p.m. | Ibid ..... | =2nd mag.* ..... | Orange colour | 0·8 second ... | From ½ (α, ε) Tauri. |
| 20 | 10 59 p.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·7 second ... | From 3 Camelop to e Persei. |
| 20 | 11 1 p.m. | Ibid ..... | =3rd mag.* ..... | Orange ..... | 1·2 second ... | From k to ½ ( Persei. |
| 20 | 11 2 p.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·5 second ... | From ε Cassiop to r Custodis. |
| 20 | 11 4 p.m. | Ibid ..... | =1st mag.* ..... | White ..... | 0·8 second ... | From δ Eridani 4° under ε Ce |
| 20 | 11 6 p.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·8 second ... | From o Ursæ M to λ Draconis. |
| 20 | 11 19 p.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·7 second ... | From κ Aur halfway to Lyncis. |
| 20 | 11 22 p.m. | Ibid ..... | =2nd mag.* ..... | Orange colour | 0·9 second ... | From φ Androm to α Lacertæ. |
| 20 | 11 30 p.m. | Ibid ..... | =2nd mag.* ..... | Orange colour | 0·8 second ... | From β Androm to ½ (β, η) Per |
| 20 | 11 36 p.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·6 second ... | From χ to ε rigæ. |
| 20 | 11 40 p.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·9 second ... | From c Camelop to σ Draconis. |

| arance; Train, if any, and its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| ..... | 6° ..... | Perpendicular ..... | ..... | W. C. Nash. |
| ..... | 4° ..... | Directed from $\eta$ Draconis. | ..... | A. S. Herschel. |
| ..... | ..... | ..... | Nine meteors in forty-five minutes: clear sky; one observer. | Id. |
| train of white colour | 35° to 40° .. | ..... | ..... | Arthur Harding. |
| train or sparks ..... | ..... | From Radiant O, in Orion. | The previous three nights generally overcast. | A. S. Herschel. |
| train or sparks ..... | ..... | From Radiant O, in Orion. | ..... | Id. |
| train or sparks ..... | 5° ..... | Directed from $\xi_2$ Ceti, Radiant T, in Cetus. | ..... | Id. |
| train or sparks ..... | ..... | From Radiant O, in Orion. | ..... | Id. |
| train or sparks ..... | ..... | From Radiant F, in Auriga. | ..... | Id. |
| train or sparks ..... | ..... | From Radiant $R_2$, in Musca. | ..... | Id. |
| a streak for 1 second | ..... | From Radiant O, in Orion. | ..... | Id. |
| .. | ..... | ..... | ..... | Id. |
| rkling brushy appearance. | ..... | Serpentine course. Radiant, Polaris. | ..... | Id. |
| train or sparks ..... | ..... | ..... | ..... | Id. |
| a streak for 2 seconds | ..... | From Radiant O, in Orion. | ..... | Id. |
| a streak for 1 second | ..... | From Radiant O, in Orion. | ..... | Id. |
| a streak for 2 seconds | ..... | From Radiant O, in Orion. | ..... | Id. |
| a streak for 3 seconds | ..... | From Radiant O, in Orion. | ..... | Id. |
| a streak for 3 seconds | ..... | From Radiant O, in Orion. Another, = 1st mag. star in Gemini. | ..... | Id. |
| a streak for 1 second | ..... | From Radiant O, in Orion. | ..... | Id. |
| a streak for 2 seconds | ..... | From Radiant O, in Orion. | ..... | Id. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, or Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1865. | h m s | | | | | |
| Oct. 20 | 11 41 p.m. | Hawkhurst (Kent). | =3rd mag.* ..... | White ..... | 0·7 second ... | From $\frac{1}{2}$ (L, c) t melopardi to laris. |
| 20 | 11 43 p.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·6 second ... | From Polaris t Draconis. |
| 20 | 11 43 30 p.m. | Ibid ..... | =4th mag.* ..... | White ..... | 0·9 second ... | From $\epsilon$ Ursæ joris, on a l continued t Draconis, dis pearing 6° of that star. |
| 20 | 11 47 p.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·5 second ... | From $\epsilon$ Persei $\frac{1}{2}$ ($\mu$ Persei Aurigæ). |
| 20 | 11 48 p.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·8 second ... | From $\delta$ to $\frac{1}{2}$ ($\theta$, Ceti. |
| 20 | 11 57 p.m. | Ibid ..... | =2nd mag.* ..... | Yellow ..... | 0·7 second ... | On a line fro to $\theta$ Aurig beginning before $\tau$, ending 5° beyo $\theta$ Aurigæ. |
| 20 | 11 58 p.m. | Ibid ..... | =1st mag.* ..... | Orange colour | 0·8 second ... | From $\frac{1}{2}$ ($\alpha$, $\eta$) Cep to $\epsilon$ Cygni; beginning 5° bef the former, ending 5° beyo the latter poin |
| 20 | 12 0 p.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·5 second ... | From $\tau$ to $\theta$ A dromedæ. |
| 21 | 12 1 30 a m. | Ibid ..... | =1st mag.* ..... | Orange colour | 0·8 second ... | From $\delta$ Piscium $\frac{1}{2}$ ($\beta$ Piscium. Pegasi). |
| 21 | 12 4 a.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·6 second ... | From $\beta$ to 33 Cy |
| 21 | 12 9 a.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·5 second ... | From $\psi$ to BAC 758 Cephei). |
| 21 | 12 18 a.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·4 second ... | From $e$ Lyncis to (D Ursæ Majo $p$ Camelopardi |
| 21 | 12 19 a.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·6 second ... | From $\zeta$ Aurigæ $\xi$ Persei. |
| 21 | 12 38 a.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·6 second ... | From $\alpha$ to $\gamma$ U Majoris. |
| 21 | 12 33 a.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 1 second ..... | Began at $\epsilon$ Cancr |
| 21 | 12 43 a.m. | Ibid..... | =2nd mag.* ..... | White ..... | 0·7 second ... | From $\beta$ Aurigæ $g$ Lyrius. |
| 25 | 6 1 p.m. | Bayswater ..... | Three times as bright as a 1st mag.* | Blue ..... | 2 seconds ... | From $\gamma$ Ursæ M noris, curved beath Polaris. |
| 25 | 8 43 p.m. | Weston-super-Mare. | =1st mag.* ..... | Bright blue ... | 1·5 second ... | $\alpha$ = From 0° + to 3 + |
| 28 | 10 38 p.m. | Hawkhurst (Kent). | =3rd mag.* ..... | White ..... | 0·5 second ... | From A Lyncis t Ursæ Majoris |

| rance; Train, if any, nd its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| streak for 2 seconds | | From Radiant O, in Orion. | | A. S. Herschel. |
| streak for 1 second | | From Radiant O, in Orion. | | Id. |
| streak on its whole rse for 2 seconds. | | From Radiant L, in Lee | | Id. |
| | | From Radiant $R_3$, in Musca. | | Id. |
| a streak for 2 seconds | | From Radiant O, in Orion. | | Id. |
| a streak for 2 seconds | | From Radiant O, in Orion. | | Id. |
| a streak for 4 seconds | | From Radiant O, in Orion. | | Id. |
| a streak for 1 second | | From Radiant O, in Orion. | | Id. |
| a streak for 3 seconds | | From Radiant O, in Orion. | | Id. |
| a streak for 1 second | | From Radiant O, in Orion. | | Id. |
| a streak for 1 second | | From Radiant O, in Orion. | | Id. |
| a streak for 1 second | | From Radiant O, in Orion. | | Id. |
| a streak for 2 seconds | | From Radiant F, in Auriga. | | Id. |
| a streak for 2 seconds | | From Radiant O, in Orion. | | Id. |
| train or sparks | | Directed from $\frac{1}{2}$ ($\beta$, $\varepsilon$) Geminorum. Radiant O, in Orion. | | Id. |
| a streak for 1½ second | | From Radiant F, in Auriga. | In 2 hours 15 minutes 41 meteors: clear sky; no moon; one observer. | Id. |
| train | | Curved | Lost sight of behind a house. | Arthur Harding. |
| | | | | W. H. Wood. |
| train or sparks | | | | A. S. Herschel. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, a Altitude an Azimuth. |
|---|---|---|---|---|---|---|
| 1865. | h m s | | | | | |
| Oct. 28 | 10 55 p.m. | Hawkhurst (Kent). | =2nd mag.* ..... | White ..... | 0·6 second ... | From E Psalte δ Eridani. |
| Nov. 5 | 8 19 p.m. | Regent's Park, London. | =1st mag.* ..... | White ..... | 0·5 second ... | From δ Muscæ (γ, σ) Arieti |
| 5 | 8 34 p.m. | Weston-super-Mare. | =Sirius ..... | Red and yellow | 1·5 second ... | α= From 90° + to 98 + |
| 5 | 8 40 p.m. | Regent's Park, London. | =1st mag.* ..... | White ..... | 0·5 second ... | From ε Cas to π Ursæ joris. |
| 6 | Between 6 and 7 p.m. | Lancaster..... | Large meteor ..... | ..... | ..... | ..... |
| 8 | 7 26 p.m. | Greenwich ..... | =2nd mag.* ..... | Yellow ..... | Momentary... | Directed fro point about above ε Her towards β Ly |
| 9 | 7 40 30 p.m. | Blackheath ..... | =3rd mag.* ..... | Yellow ..... | 0·3 second ... | From a point a l above and to N. of α Cor Borealis, tow horizon. |
| 9 | 9 46 p.m. | Ibid ..... | =4th mag.* ..... | Bluish ..... | $\frac{1}{10}$ second ... | Appeared near Eridani. |
| 12 | 6 40 p.m. | Brook, Norwich | Bright as Venus ... | White ..... | 1 second ..... | From ζ to β U Majoris. |
| 12 | 10 45 p.m. | Cambridge ..... | Bright meteor..... | ..... | ..... | Crossing the l star of the tai Ursa Major. |
| 12 | 10 55 p.m. | Ibid ..... | Several bright meteors. | ..... | ..... | ..... |
| 12 | 11 17 p.m. | Flimwell, Sussex | =3rd mag.* ..... | Blue ..... | ..... | From near Cap to the Pleiade |
| 12 | 11 22 p.m. | Ibid ..... | Brighter than Venus. | ..... | ..... | Disappeared l below β Aricti |
| 12 | 11 22 30 p.m. | Ibid ..... | Brighter than Venus. | Blue ..... | Moderate speed. | Disappeared a Orionis. |
| 12 | 11 31 p.m. | Ibid ..... | =3rd mag.* ..... | Rapid motion | ..... | From 8° below β γ Geminorum. |
| 12 | 11 46 p.m. | Ibid ..... | =1st mag.* . .... | Rapid motion | ..... | From Aldebaran 38 Arietis. |
| 12 | 11 49 p.m. | Ibid ..... | As bright as Jupiter | Moderate speed. | ..... | From 11° W. Pollux. |
| 13 | 12 0 a.m. | Hawkhurst (Kent). | =1st mag.*..... | White ..... | 1·5 second ... | From ε Ursæ Majo to ss Custodis. |

| ...arance; Train, if any, and its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| ...ain or sparks | | | Three meteors in thirty minutes: half-moon; clear sky; one observer. | A. S. Herschel. |
| a slight train | | | | T. Crumplen. |
| | | | Tail 10° 1 sec.; meteor increased in intensity and showed a red crescent on anterior hemisphere. | W. H. Wood. |
| a slight train | | | | T. Crumplen. |
| | | E. to W. | | Manchester 'Examiner & Times.' |
| | A flash only | Slightly inclined to zenith. | | Thomas Wright. |
| | 7° | Inclined | | Id. |
| | | | | |
| train | 2° | Perpendicular | | Id. |
| train or sparks | | | Seen also at Manchester | Communicated by A. S. Herschel. |
| ...t a phosphorescent streak. | 20° | Horizontal, left to right | | W. H. Hudson. |
| | 10° | Inclined | | Id. |
| train or sparks | 30° | | | F. Howlett. |
| | | Course halfway from the Pleiades. | | Id. |
| | | Course halfway from the Pleiades. | | Id. |
| ...t a train | 23° | | | Id. |
| | 20° | | | Id. |
| | |  | | |
| ...t a train | 18° | | | Id. |
| | | | | |
| streak for 2 seconds | | | | A. S. Herschel. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1865. Nov. 13 | h m s 12 1 a.m. | Flimwell, Sussex | =1st mag.* ..... | Blue ..... | Very rapid ... | From κ Ursæ joris nearly Cassiopeia. |
| 13 | 12 2 a.m. | Ibid ..... | =2nd mag.* ..... | ..... | ..... | Began 4° W. Geminorum. |
| 13 | 12 9 a.m. | Wisbeach ..... | =1st mag.* ..... | Yellow ..... | 3½ seconds ... | From ζ Gemi to ∝ Lyncis. |
| 13 | 12 11 a.m. | Newcastle-on-Tyne. | ..... | ..... | ..... | From Pleiade S.W. of Ari |
| 13 | 12 11 30 a.m. | Hawkhurst (Kent). | =1st mag.* ..... | White ..... | 1·3 second ... | From τ Ursæ joris to ω Ce |
| 13 | 12 11 30 a.m. | Wisbeach..... | =1st mag.*..... | Yellow ..... | 2 seconds..... | From β Cancri (k, δ) Monoce |
| 13 | 12 13 30 a.m. | Hawkhurst (Kent). | Bright as Jupiter... | Orange colour | 1·8 second .. | To κ Leonis; quarters of way from onis. |
| 13 | 12 18 a.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 1·2 second ... | From 1° und Monocerotis ζ Leporis. |
| 13 | 12 18 30 a.m. | Flimwell, Sussex | =1st mag.*..... | Moderate speed. | ..... | From about 10° of γ Gemino to ε Orionis, onwards. |
| 13 | 12 19 10 a.m. | Wisbeach..... | =2nd mag.* ..... | White ..... | 1½ second .. | From ε Cas through k Lyr to near ε Cas lopardi. |
| 13 | 12 24 a.m. | Hawkhurst (Kent). | Bright as Venus ... | Yellow ..... | 1·4 second ... | First appeared Sceptri. |
| 13 | 12 25 a.m. | Flimwell, Sussex | Brighter than Venus. | Yellowish ... | Moderate speed. | From very nea Orionis towa S.W. |
| 13 | 12 25 a.m. | Wisbeach..... | =2nd mag.* ..... | ..... | 1½ second ... | From ε Canis Mi to near ∝ Tau |
| 13 | 12 27 a.m. | Hawkhurst (Kent). | =2nd mag.* ..... | White ..... | 0·5 second ... | First appeared Canis Minoris |
| 13 | 12 27 30 a.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 1 second ..... | From ½ (γ, ζ) Cancri. |
| 13 | 12 28 a.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 1·2 second ... | From δ Persei (ε Persei, γ dromedæ). |
| 13 | 12 29 a.m. | Flimwell, Sussex | Brighter than Jupiter. | ..... | Very slow motion. | Appeared abo 4° below Pleiades. |
| 13 | 12 34 a.m. | Hawkhurst (Kent). | =3rd mag.* ..... | White ..... | 0·7 second ... | From 1° N. of θ Geminorum. |
| 13 | 12 36 a.m. | Ibid ..... | =1st mag.*..... | White ..... | 1 second ..... | From θ to β Ca Majoris. |
| 13 | 12 41 a.m. | Flimwell, Sussex | =2nd mag.* ..... | ..... | Rapid motion.. | Appeared near Ri |
| 13 | 12 42 a.m. | Newcastle-on-Tyne. | ..... | ..... | ..... | From β Tauri, p Pleiades, and of Aries, dow W. horizon. |
| 13 | 12 42 30 a.m. | Flimwell, Sussex | =2nd mag.* ..... | ..... | Rapid motion.. | Appeared about below Rigel. |

| rance; Train, if any, d its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| fine train | 50° | | Identical with the preceding meteor. | F. Howlett. |
| | 10° | Upwards towards Lynx | | Id. |
| train | 30° | Nearly horizontal | | S. H. Miller. |
| | | | | T. P. Barkas. |
| streak for 3 seconds | | | Identical with Cambridge No. 3, $12^h\ 11^m\ 32^s$ a.m. (See Appendix IV. 2). | A. S. Herschel. |
| t train | | Horizontal | Nucleus coruscant | S. H. Miller. |
| a green streak for econds. | | | Streak decidedly green. | A. S. Herschel. |
| a streak for 2 seconds | | | | Id. |
| a train | 25° | | Identical with Hawkhurst, $12^h\ 18^m$ a.m. | F. Howlett. |
| on the whole course | 20° | Nearly perpendicular | | S. H. Miller. |
| -shaped; left a streak r 4 seconds. | 20° | Directed from β Cancri | | A. S. Herschel. |
| a very fine train | 25° | | Identical with Hawkhurst, $12^h\ 24^m$ a.m. | F. Howlett. |
| a train of 15° | | | | S. H. Miller. |
| a streak for 2 seconds | 6° | Directed from ε Cancri | | A. S. Herschel. |
| a yellow train for seconds. | | | | Id. |
| a streak for 2 seconds | | | | Id. |
| a train | 3° | Downwards towards S; crooked, thus ⟨5 | | F. Howlett. |
| a streak for 1 second | | | | A. S. Herschel. |
| a streak for 2 seconds | | | | Id. |
| | 20° | Towards S.W. | | F. Howlett. |
| | | | | T. P. Barkas. |
| | 20° | Towards S.W. | | F. Howlett. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, c Altitude a Azimuth. |
|---|---|---|---|---|---|---|
| 1865. | h m s | | | | | |
| Nov. 13 | 12 44 a.m. | Flimwell, Sussex | =2nd mag.* ..... | ..... | ..... | Appeared abo above Rigel. |
| 13 | 12 44 30 a.m. | Hawkhurst (Kent). | Brighter than Venus. | Greenish white | 2 seconds..... | First appeared Leonis. |
| 13 | 12 44 30 a.m. | Wisbeach..... | Cor Corali ..... | Yellow ..... | Rapid ..... | Canis Minor near Tauri. |
| 13 | 12 46 a.m. | Hawkhurst (Kent). | =1st mag.* ..... | Greenish ..... | 1·5 second ... | From Ursæ joris to laris, a Tau |
| 13 | 12 46 a.m. | Flimwell, Sussex | =1st mag.*..... | ..... | Very rapid motion. | From near Majoris, to Cassiopei |
| 13 | 12 48 a.m. | Newcastle-on-Tyne. | ..... | ..... | ..... | From γ Gemin to Pleiades. |
| 13 | 12 48 a.m. | Ibid ..... | ..... | ..... | ..... | From γ Gemin to Pole-star. |
| 13 | 12 51 30 a.m. | Hawkhurst (Kent). | =Sirius ..... | White ..... | 1 second ..... | From ζ Le halfway to Leonis Mino |
| 13 | 12 53 30 a.m. | Flimwell, Sussex | =1st mag.*..... | ..... | ..... | From 10° b Procyon to above Sirius. |
| 13 | 12 54 15 a.m. | Hawkhurst (Kent). | =2nd mag.* ..... | White ..... | 1 second ..... | From q to nocerotis. |
| 13 | 12 54 30 a.m. | Ibid ..... | =3rd mag.* ..... | White ..... | ..... | From ι Ursæ joris to e Ly |
| 13 | 12 54 45 a.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 1·4 second ... | From α to g conis, and further. |
| 13 | 12 57 a.m. | Newcastle-on-Tyne. | ..... | ..... | ..... | From a little of Castor, thro Aldebaran. |
| 13 | 1 0 a.m. | Flimwell, Sussex | Bright as Jupiter... | ..... | Moderate speed. | From near, and bove α to β Ori |
| 13 | 1 0 15 a.m. | Ibid ..... | Bright as Jupiter... | ..... | Moderate speed. | Appeared near gel. |
| 13 | 1 1 30 a.m. | Hawkhurst (Kent). | =2nd mag.* ..... | White ..... | 1·2 second ... | From γ Trian to ½ (ρ Pisci δ Andromed |
| 13 | 1 3 a.m. | Wisbeach ..... | =1st mag.* ..... | Light blue ... | 1½ second ... | ½ (β, ψ) to ε dani. |
| 13 | 1 4 45 a.m. | Ibid ..... | =1st mag.* ..... | White ..... | 2 seconds..... | From near β C Minoris to Orionis, μ Erid |
| 13 | 1 6 a.m. | Flimwell, Sussex | =1st mag.* ..... | ..... | ..... | Appeared bet α and β G norum. |
| 13 | 1 6 30 a.m. | Hawkhurst (Kent). | =3rd mag.* ..... | Yellow ..... | 1 second ..... | From ι Gemino to ψ Cancri. |
| 13 | 1 7 a.m. | Flimwell, Sussex | Bright as Jupiter... | ..... | Rapid motion | From κ Ursæ joris to Ca peia. |
| 13 | 1 7 45 a.m. | Hawkhurst (Kent). | =1st mag.* ..... | Bluish white... | 1·1 second ... | From κ Ursæ joris to q Ca lopardi. |
| 13 | 1 8 a.m. | Flimwell, Sussex | Bright as Jupiter... | ..... | ..... | Appeared near Cassiopeiæ. |

| arance; Train, if any, and its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| ..... | 20° ..... | Towards S.W..... | ..... | F. Howlett. |
| st stationary; left a eak at the place for seconds. | 3°..... | Directed from $\mu$ Leonis | ..... | A. S. Herschel. |
| for 1½ second ..... | ..... | Horizontal ..... | ..... | S. H. Miller. |
| k 2½ seconds ..... | ..... | ..... | Identical with Cambridge, $12^h\ 46^m\ 2^s$ a.m. (See Appendix IV. 2.) | A. S. Herschel. |
| a fine train ..... | 45° ..... | ..... | Identical with Hawkhurst, $12^h\ 46^m$ a.m. | F. Howlett. |
| a ..... | ..... | ..... | ..... | T. P. Barkas. |
| n ..... | ..... | ..... | ..... | Id. |
| a streak for 4 seconds | ..... | ..... | ..... | A. S. Herschel. |
| ..... | 28° ..... | ..... | Identical with Hawkhurst, $12^h\ 54^m\ 15^s$ a.m. | F. Howlett. |
| ..... | ..... | ..... | ..... | A. S. Herschel. |
| a streak for 3 seconds | ..... | ..... | ..... | Id. |
| a streak for 3 seconds | ..... | ..... | ..... | Id. |
| a train ..... | ..... | ..... | ..... | T. P. Barkas. |
| ..... | 15° ..... | ..... | ..... | F. Howlett. |
| a train ..... | 30° ..... | Towards W. ..... | ..... | Id. |
| a streak for 2 seconds | ..... | ..... | ..... | A. S. Herschel. |
| m ..... | ..... | Descending ..... | ..... | S. H. Miller. |
| ..... | ..... | Horizontal ..... | ..... | Id. |
| train or sparks ..... | 10° ..... | Towards N.E. part of horizon. | Identical with Hawkhurst, $1^h\ 6^m\ 30^s$ a.m. | F. Howlett. |
| train or sparks ..... | ..... | ..... | ..... | A. S. Herschel. |
| a very long train..... | 50° ..... | ..... | Identical with Hawkhurst, $1^h\ 7^m\ 45^s$ a.m. | F. Howlett. |
| a streak for 3 seconds | ..... | ..... | ..... | A. S. Herschel. |
| ..... | 38° ..... | Towards N. point of horizon. | Identical with Hawkhurst, $1^h\ 8^m\ 45^s$ a.m. | F. Howlett. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, Altitude a Azimuth. |
|---|---|---|---|---|---|---|
| 1865. Nov. 13 | h m s 1 8 45 a.m. | Hawkhurst (Kent). | =3rd mag.* ..... | Orange ..... | 1·2 second ... | From $\rho$ Cassi to $\frac{1}{2}$ $\eta$ Ce $c$ Lacertæ. |
| 13 | 1 14 a.m. | Flimwell, Sussex | =1st mag.* ..... | ..... | Rapid motion.. | Appeared at $\beta$ minorum. |
| 13 | 1 14 15 a.m. | Hawkhurst (Kent). | =3rd mag.* ..... | White ..... | 0·9 second ... | From 2° above lux, halfway Aurigæ. |
| 13 | 1 15 a.m. | Wisbeach (Cambridgeshire). | =2nd mag.* ..... | White ..... | 2 seconds ... | From $\frac{1}{2}$ ($\gamma$, $\pi$) dani) to Eridani, E terii). |
| 13 | 1 16 30 a.m. | Hawkhurst (Kent). | =2nd mag.* ..... | Yellow..... | 1 second ..... | From $r$ Mono tis to a poi R.A. 125°, Decl. 17°. |
| 13 | 1 18 a.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·7 second ... | From $\lambda$ Canis noris to 2° 25 Monocer |
| 13 | 1 18 15 a.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·9 second ... | From $\epsilon$ Hydræ ($\sigma$ Hydræ, $p$ nocerotis). |
| 13 | 1 18 45 a.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·9 second ... | From $\frac{1}{2}$ ($\pi$, $\tau$) Majoris to $\frac{1}{2}$ P) Camelopa |
| 13 | 1 23 a.m. | Flimwell, Sussex | =2nd mag.* ..... | ..... | Rapid ..... | From $\beta$ Canis noris to $\epsilon$ onis. |
| 13 | 1 24 45 a.m. | Hawkhurst (Kent). | =2nd mag.* ..... | White ..... | 0·8 second ... | From $\sigma$ Ursæ joris to a p in R.A. 22 N. Decl. 60°. |
| 13 | 1 26 15 a.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·9 second ... | From $\frac{1}{2}$ ($\sigma$, $\tau$) Majoris to 0 melopardi. |
| 13 | 1 28 15 a.m. | Ibid ..... | Brighter than a 1st mag.* | White ..... | 1 second ..... | From $\phi$ Persei Andromedæ. |
| 13 | 1 29 a.m. | King's Cross (London). | =1st mag.* ..... | Bluish ..... | 0·6 second ... | From $\delta$ Leonis noris to $\iota$ U Majoris. |
| 13 | 1 30 54 a.m. | Royal Observatory, Greenwich. | =1st mag.* ..... | White ..... | 2 to 3 seconds | Appeared about above $\alpha$ Orio and passed ab the same tance above Orionis towa $\gamma$ Eridani. |
| 13 | 1 31 a.m. | Hawkhurst (Kent). | =3rd mag.* ..... | White ..... | 0·7 second ... | From $\eta$ Tauri t ($\sigma$, $\alpha$) Arietis. |
| 13 | 1 32 a.m. | King's Cross (London). | =2nd mag.* ..... | ..... | 0·5 second ... | From $\alpha$ to $\frac{1}{2}$ ($\nu$, Tauri. |
| 13 | 1 33 30 a.m. | Ibid ..... | =1st mag.* ..... | Bluish ..... | 0·7 second ... | From $\alpha$ Orionis 3° below $\alpha$ H nocerotis. |

| arance; Train, if any, and its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| rain or sparks | | | Identical with Cambridge, No. 53, $1^h 8^m 37^s$ a.m. (See Suppt. to Cat.; and Appendix IV. 2.) | A. S. Herschel. |
| a train | 15° | Towards Aldebaran | | F. Howlett. |
| a streak for 1 second | | | | A. S. Herschel. |
| a bright streak | | | | S. H. Miller. |
| a streak for 2 seconds | | | | A. S. Herschel. |
| t a streak for 1 second | | | | Id. |
| t a short bright train or 2 seconds. | | | | Id. |
| h a streak for 2 seconds | | | | Id. |
| h a train | 40° | | Very exact observation. | F. Howlett. |
| h a streak for 2 seconds | | | Identical with Cambridge, No. 70, $1^h 24^m 56^s$ a.m. (See Suppt. to Cat.; and Appendix IV. 2.) | A. S. Herschel. |
| ft a streak for 2 seconds | | | | Id. |
| ft a streak for 5 seconds | | | Identical with Cambridge, No. 75, $1^h 27^m 37^s$ a.m. (See Suppt. to Cat.; and Appendix IV. 2.) | Id. |
| | | | | T. Crumplen. |
| ft a train for 3 seconds | 25° | Inclined S.E. to S. by W. | A very brilliant meteor. Identical with the next. | M. Rikatcheff. |
| ft a streak for 1 second | | | Identical with Greenwich, $1^h 30^m 54^s$ a.m. (See Appendix IV. 2.) | A. S. Herschel. |
| | | From Radiant in Taurus | | T. Crumplen. |
| ft a bright train for 1 sec. | | | | Id. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, or Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1865. | h m s | | | | | |
| Nov. 13 | 1 35 a.m. | Hawkhurst (Kent). | =3rd mag.*..... | White ..... | 0·8 second ... | From Q Cam pardi to l Be Polaris and further. |
| 13 | 1 36 a.m. | King's Cross (London). | Planetary disk = to Venus. | ..... | ..... | From ϑ to E Le |
| 13 | 1 37 25 a.m. | Hawkhurst (Kent). | Bright as Jupiter... | White ..... | 0·7 second ... | From ε to f Pisc |
| 13 | 1 42 50 a.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·8 second ... | From e to ½ (λ, Tauri, and a far again. |
| 13 | 1 49 a.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 1 second ..... | From δ Musc γ Piscium. |
| 13 | 1 54 a.m. | Ibid ..... | =1st mag.* ..... | White ..... | 1 second ..... | From ½ (α, c) T to ½ (λ, ε) C |
| 13 | 1 54 a.m. | King's Cross (London). | =Sirius ..... | Silvery white.. | 1 second ..... | From ξ Gem rum to γ O nis, and acro Orionis, wi star it tot obscured. |
| 13 | 1 55 a.m. | Ibid ..... | =2nd mag.* ..... | ..... | ..... | From ψ Cancri ½ (α, β) C Minoris. |
| 13 | 1 55 45 a.m. | Hawkhurst (Kent). | =3rd mag.* ..... | White ..... | 0·8 second ... | From 1° N. o Monocerotis. |
| 13 | 1 59 a.m. | King's Cross (London). | =2nd mag.* ..... | ..... | 0·8 second ... | Disappeared a Leonis, co halfway f Procyon. |
| 13 | 2 1 15 a.m. | Hawkhurst (Kent). | =2nd mag.* ..... | Yellow ..... | 1·5 second ... | From θ Persei t Cassiopeiæ. |
| 13 | 2 3 38 a.m. | Royal Observatory, Greenwich. | Brighter than a 1st mag.* | Bright blue ... | 2 seconds..... | From the direc of γ Cassiop to a point a way betwee and η Pegas |
| 13 | 2 3 40 a.m. | Hawkhurst (Kent). | =1st mag.* ..... | White ..... | 1 second ..... | From g Lacert g Honorum. |
| 13 | 2 4 30 a.m. | King's Cross (London). | ..... | ..... | ..... | Centre at β C Minoris. |
| 13 | 2 4 48 a.m. | Royal Observatory, Greenwich. | Brighter than a 1st mag.* | Blue ..... | 1½ second ... | Disappeared tween β C and Procyo |
| 13 | 2 4 50 a.m. | Hawkhurst (Kent). | =2nd mag.* ..... | Yellow ..... | 0·8 second ... | From α Aur b Telescopii. |
| 13 | 2 5 a.m. | Ibid ..... | =1st mag.* ..... | White ..... | 1·1 second ... | From ε Gemin to B Tauri. |
| 13 | 2 8 a.m. | Ibid ..... | =1st mag.* ..... | White ..... | 0·8 second ... | Disappeared a S. of ξ Ursæ joris, one- of the way ζ Leonis. |
| 13 | 2 9 20 a.m. | Ibid ..... | =1st mag.* ..... | White ..... | 0·9 second ... | From Procyon Monocerotis. |

| arance; Train, if any, and its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| a streak for 2 seconds | ..... | ..... | ..... | A. S. Herschel. |
| ..... | ..... | ..... | Further view obstructed by buildings. | T. Crumplen. |
| a streak for 5 seconds | ..... | ..... | Three bright meteors nearly together. | A. S. Herschel. |
| a streak for 1½ second | ..... | ..... | ..... | Id. |
| a very bright streak r 3 seconds. | ..... | ..... | ..... | Id. |
| ..... | ..... | ..... | ..... | Id. |
| ..... | ..... | ..... | Good observation ..... | T. Crumplen. |
| ..... | ..... | ..... | ..... | Id. |
| t a streak for 1 second | ..... | ..... | ..... | A. S. Herschel. |
| ..... | ..... | ..... | ..... | T. Crumplen. |
| w gradually less; no rain or sparks. | ..... | Radiant, ξ Persei ..... | ..... | A. S. Herschel. |
| meteor with a very fine wavy train. | ..... | ..... | This meteor was very similar to the one at 1h 35m 30s a.m. Identical with the next. | Arthur Harding. |
| ft a streak for 3 seconds | ..... | ..... | Identical with the preceding. (See Appendix IV. 2.) | A. S. Herschel. |
| e luminous streak only seen. | 15° ..... | Directed from γ Leonis | ..... | T. Crumplen. |
| ft a fine train for 1 sec.. | About 15°... | Directed from ν Geminorum. | Identical with the next | W. C. Nash. |
| ew gradually less; no train or sparks. | ..... | Radiant, ξ Persei..... | Identical with the preceding. (See Appendix IV. 2.) | A. S. Herschel. |
| ft a broad streak for 3 seconds. | ..... | ..... | ..... | Id. |
| ft a bright streak for 3 seconds. | ..... | ..... | ..... | Id. |
| ft a bright streak for 3 seconds. | ..... | ..... | Identical with the following. (See Appendix IV. 2.) | Id. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, or Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1865. Nov.13 | h m s 2 9 27 a.m. | Royal Observatory, Greenwich. | As bright as Sirius.. | Blue ..... | 2 seconds ... | Passed from below Procy disappeared Sirius. |
| 13 | 2 15 15 a.m. | Hawkhurst (Kent). | =2nd mag.* ..... | White ..... | 0·7 second ... | From A Ursæ noris to φ conis. |
| 13 | 2 16 15 a.m. | Ibid ..... | =1st mag.* ..... | White ..... | 0·8 second ... | From r Custo near e Cephe |
| 13 | 2 18 30 a.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·7 second ... | From λ Dracon ½ (ε, ζ) U Minoris. |
| 13 | 2 19 45 a.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·7 second ... | From σ Ursæ joris to randi. |
| 13 | 2 20 20 a.m. | Ibid ..... | =1st mag.* ..... | White ..... | 0·7 second ... | From λ Dracon ½ (ε, ζ) U Minoris. |
| 13 | 2 22 a.m. | Ibid ..... | =Sirius ..... | Orange ..... | 1 second ..... | From 1½° S. Leonis Mi to ξ Ursæ joris. |
| 13 | 2 28 15 a.m. | Ibid ..... | =1st mag.* ..... | White ..... | 1 second ..... | From L Ca pardi to γ siopeiæ. |
| 13 | 2 30 15 a.m. | Ibid ..... | Brighter than a 1st mag.* | White ..... | 1 second ..... | From 1° S. Monocerotis ½ (β Eridan Orionis). |
| 13 | 2 33 a.m. | Ibid ..... | =Sirius ..... | White ..... | 1 second ..... | From 9 Auri ½ (γ And medæ, υ P sei). |
| 13 | 2 33 10 a.m. | Ibid ..... | =1st mag.*..... | White . ..... | 1 second ..... | Through the cen of the Tri gle α, β, γ T anguli. |
| 13 | 2 37 a.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·7 second ... | From θ Hydræ 1° E. of r Mo cerotis. |
| 13 | 2 37 10 a.m. | Royal Observatory, Greenwich. | =1st mag.* ..... | Blue ..... | 1 second ..... | Passed a few grees W. of Hydræ, and onwards towa the horizon. |
| 13 | 2 41 15 a.m. | Hawkhurst (Kent). | = Sirius ..... | White ..... | 0·6 second ... | From O Cam pardi to ½ (ε C phei, Polaris. |
| 13 | 2 47 a.m. | Ibid ..... | =Sirius ..... | Greenish white | 1 second ..... | Disappeared at Geminorum, La way from γ Ca cri. |
| 13 | 2 48 20 a.m. | Ibid ..... | Brighter than 1st mag.* | White ..... | 0·6 second ... | From θ to o Cass peiæ, and 5° furth |
| 13 | 2 52 a.m. | Ibid ..... | Bright as Jupiter... | Greenish white | 0·6 second ... | Disappeared at (A, β) Ursæ M noris, two-thir of the way fro β Ursæ Majoris |

| arance; Train, if any, and its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| a fine train for 2 secs. | 20° ..... | Inclined ..... | Identical with the preceding. | W. C. Nash. |
| a streak for 2 seconds | ..... | ..... | ..... | A. S. Herschel. |
| a streak for 4 seconds | ..... | ..... | ..... | Id. |
| a streak for 3 seconds | ..... | ..... | ..... | Id. |
| ..... | ..... | ..... | ..... | Id. |
| a streak for 3 seconds | ..... | ..... | ..... | Id. |
| a streak for 4 seconds | ..... | ..... | ..... | Id. |
| a streak for 3½ secs... | ..... | ..... | ..... | Id. |
| a streak for 3 seconds | ..... | ..... | Three other bright meteors about the same time. | Id. |
| a broad bright streak or 5 seconds. | ..... | ..... | Good observation ..... | Id. |
| ..... | ..... | ..... | Four other bright meteors about the same time. | Id. |
| ft a streak for 2 seconds | ..... | ..... | Identical with the following. (See Appendix IV. 2.) | Id. |
| ft a train ..... | 10° ..... | Inclined; directed from α Leonis. | Identical with the preceding. | W. C. Nash. |
| ft a bright train for 2½ seconds. | ..... | ..... | ..... | A. S. Herschel. |
| ft a streak for 4 seconds | ..... | ..... | ..... | Id. |
| ft a streak for 3 seconds | ..... | ..... | ..... | Id. |
| ft a streak for 6 seconds; faded gradually from the ends towards the centre. | ..... | ..... | ..... | Id. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, or Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1865. | h m s | | | | | |
| Nov. 13 | 4 16 12 a.m. | Streatham, near London. | =Sirius | Yellow | 1 second | From 114° + to 102 + |
| 13 | 4 22 12 a.m. | Ibid | =Procyon | Yellow | | From 137° + to 126 − |
| 13 | 4 30 14 a.m. | Ibid | As bright as Jupiter | Yellow | | From 116° + to 98 + |
| 13 | 4 37 48 a.m. | Ibid | =Vega Lyræ | White | | From 150° + to 147 |
| 13 | 4 42 22 a.m. | Ibid | As bright as Jupiter | Yellow | | From 185° + to 192 + |
| 13 | 4 59 49 a.m. | Ibid | As bright as Venus | Pale yellow | 4 seconds | From 100° + to 150 + |
| 13 | About 5 a.m. | Ibid | Apparent size of the moon. | White | 2 seconds | From 187° + to 160 + |
| 13 | 5 7 17 a.m. | Ibid | =⅛, apparent diameter of the moon. | Blue | | From 153° + to 175 + |
| 13 | 5 12 12 a.m. | Ibid | Apparent size of the moon. | Reddish purple | | From 156° + to 167 + |
| 13 | 5 16 48 a.m. | Ibid | As bright as Venus | Purplish yellow [?]. | | From 124° + to 118 + |
| 13 | 5 18 17 a.m. | Ibid | =Sirius | Orange colour | | From 196° + to 205 + |
| 13 | 5 26 40 a.m. | Ibid | =Sirius | Yellow | | From 150° + to 159 + |
| 13 | 5 39 48 a.m. | Ibid | Nearly as bright as Venus. | Golden yellow | | From 114° + to 100 − |
| 13 | 5 44 30 a.m. | Ibid | =Sirius | Bluish white | | From 120° + to 100 + |
| 13 | 5 42 p.m. | Primrose Hill, London. | From 3rd mag.* to =3× ♀ at maximum. | White | 2·5 seconds | From below Draconis, passing between Lyræ and γ Draconis, and on towards B Herculis. |
| 18 | 5 42 p.m. | Market Drayton, Salop. | Very bright | White | | From E. to W., 10° above the S. horizon |
| 13 | 5 42 p.m. | Near Plymouth.. | A fine meteor | | Moved slowly, especially towards the close | From E.N.E. to S.W. |
| 13 | About 5 42 p.m. | Taunton | Large meteor | Pale green | A few seconds | Commenced at an altitude of 45° or 50° in the E., passed in a slightly northerly direction over the head, and disappeared in the W. at the same altitude. |
| 13 | 5 45 p.m. | Boulogne Harbour. | Brilliant meteor | | Slow and dignified motion. | Crossed the mouth of the harbour in a westerly direction at an elevation of 30° or 35°. |

| rance; Train, if any, d its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| train 7° in length... | ..... | ..... | ..... | S. B. Kincaid. |
| train 3° in length... | ..... | ..... | ..... | Id. |
| train for some se- s 10° in length. | ..... | ..... | ..... | Id. |
| ) train ..... | ..... | ..... | ..... | Id. |
| bright and lasting 10° in length. | ..... | ..... | ..... | Id. |
| ) train ..... | ..... | ..... | ..... | Id. |
| a broad train all g its course 1½° e. | ..... | ..... | "Size of a large pear".. | Id. |
| a train upon its le course for one nte. | ..... | ..... | ..... | Id. |
| train for half a mi- e. | ..... | ..... | "Size of an orange" ... | Id. |
| a train for several nds. | ..... | ..... | ..... | Id. |
| a train for 4 seconds in length. | ..... | ..... | ..... | Id. |
| a train for 2 seconds in length. | ..... | ..... | ..... | Id. |
| train for 3 seconds... | ..... | ..... | ..... | Id. |
| a bright but evanes- t train. | ..... | ..... | ..... | Id. |
| a sparkling train; lured 1 second. | Nearly 50°.. | Inclined downwards ... | Globular; threw off a number of sparks. | T. Crumplen. |
| minous streak; burst e a rocket. | ..... | Horizontal ..... | Seen also at Oswestry... | Communicated by T. Crumplen. |
| t twice; disappeared ddenly. | 50° ..... | ..... | ..... | Id. |
| ared much larger en vertical, than pre- ously or subsequently, rrounded by a pale een halo, which at one oment had a faintly angled appearance. | ..... | ..... | Cloudy and dark; few stars could be seen. | W. M. Kelly. |
| ntillations tinged with ed. | ..... | Nearly horizontal ..... | ..... | Communicated by T. Crumplen. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, or Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1865. | h m s | | | | | |
| Nov. 13 | Shortly before 6 p.m. | Farnworth, near Bolton, Manchester. | Large meteor ..... | White, then red. | ..... | From S. to high up the horizon. |
| 13 | A few minutes before 6 p.m. | Sandbach, Cheshire. | Large meteor ..... | ..... | Not very rapid motion. | Commenced up, due E., disappeared S. |
| 13 | About 6 p.m. | Manchester ..... | Large meteor ..... | ..... | ..... | ..... |
| 13 | 9 to 12 p.m. | Weston-super-Mare. | ..... | ..... | ..... | ..... |
| 13 | 9 53 p.m. | Hawkhurst (Kent). | Bright as Venus ... | White ..... | Moderate speed. | Disappeared at Ursæ Majoris. |
| 13 | 10 44 p.m. | Wisbeach..... | =Sirius ..... | Ruddy ..... | 5 seconds ... | From near $\beta$ Gem norum thro Cancer to t horizon. |
| 13 | About 10 50 p.m. | Haverstock Hill, London. | Large meteor ..... | ..... | ..... | Its path commenc in or a little of Orion. |
| 13 | 10 50 p.m. | Islington Green, London. | =3 or 4 times ♀ .. | Very bright ... | ..... | From E. to W passing thro the square Ursa Major. |
| 13 | 10 50 p.m. | Great Yarmouth | =3 × ♀ ..... | Very bright ... | ..... | From E. to W. path of 35°, t centre passi just below Ursæ Majoris. |
| 13 | 10 55 p.m. | Cambridge ..... | Large and brilliant | Red, green, and yellow. | ..... | From about t middle of t square of t Great Bear t Cygni. |
| 13 | 11 17 15 p.m. | Hawkhurst (Kent). | =3rd mag.* ..... | Yellow ..... | 0·5 second ... | From $\tau$ to $\nu$ Tau |
| 13 | 11 26 30 p.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 2·75 seconds .. | From $\nu$ Aurig passed $\eta$ Tau to $\nu$ Piscium. |
| 13 | 11 35 15 p.m. | Ibid ..... | =2nd mag.* ..... | Yellow ..... | 0·8 second ... | Disappeared at Pr cyon. |
| 13 | 11 44 p.m. | Ibid ..... | =3rd mag.* ..... | Yellow ..... | 0·4 second ... | From $o$ to $q$ Orion |
| 13 | 11 47 15 p.m. | Ibid ..... | =2nd mag.* ..... | Yellow ..... | 0·4 second ... | From 12 Lyncis t L Camelopard. |
| 13 | 11 50 p.m. | Ibid ..... | =1st mag.* ..... | Yellow ..... | 2 seconds..... | Appeared at $\psi$ Du conis. |

| nnce; Train, if any, nd its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| sed the heavens like ordinary shooting- | ..... | Horizontal; E. to W.... | ..... | 'Examiner and Times.' |
| ..... | ..... | Perfectly horizontal; parallel with the plane of the horizon. | ..... | Lewis Evans. |
| out rather stronger at the middle of its rse, and then seemed row smaller. | ..... | ..... | ..... | Communicated by R. P. Greg. |
| ..... | ..... | ..... | Sky partially clear. No meteors seen from $12^h$ to $1^h$ on the 14th, occasionally clear in the E. and N.; two meteors were recorded. From $1^h\,15^m$ to $4^h\,30^m$ a.m., the sky was completely overcast, and observations were then discontinued. | W. H. Wood. |
| l streak for 2 seconds | 15° ..... | ..... | ..... | T. Humphrey. |
| ..... | ..... | Perpendicular ..... | ..... | S. H. Miller. |
| behind it a very bril- st yellowish - white il of light. | 20° or 30°.. | Nearly horizontal; E. to W. | ..... | J. W., 'Morning Herald.' |
| a long streak; threw sparks. | ..... | Horizontal ..... | Like a rocket ..... | Communicated by T. Crumplen. |
| dy like a large rocket | 35° ..... | Horizontal ..... | ..... | Id. |
| like a rocket ..... | ..... | ..... | ..... | Id. |
| rain or sparks ..... | ..... | ..... | ..... | A. S. Herschel & H.T.Humphreys. |
| n on whole course for seconds. | 50° ..... | Directed from $p$ Lyncis. | ..... | Id. |
| a streak for 2 seconds | 6°..... | Directed from $\lambda$ Ursæ Majoris. | ..... | Id. |
| train or sparks ..... | ..... | ..... | ..... | Id. |
| ..... | ..... | ..... | ..... | Id. |
| ..... | 15° ..... | Directed from $\lambda$ Persei... | ..... | Id. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, o Altitude an Azimuth. |
|---|---|---|---|---|---|---|
| 1865. Nov. 13 | h m s 11 53 10 p.m. | Hawkhurst (Kent). | =2nd mag.* ..... | White ..... | 1 second ..... | From B to γ T |
| 13 | 11 54 30 p.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 1·5 second ... | From λ to e l conis. |
| 14 | 12 0 40 a.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·5 second ... | Across Polaris. |
| 14 | 12 3 10 a.m. | Ibid ..... | =1st mag.* ..... | White ..... | 1·3 second ... | From 1° S. of λ Tauri. |
| 14 | 12 5 a.m. | Weston-super-Mare. | =4th mag.* ..... | Dark ..... | 1·5 second ... | α = From 127° + to 112 − |
| 14 | 12 13 a.m. | Hawkhurst (Kent). | =1st mag.* ..... | White ..... | 1·4 second ... | From 1° above cyon to 1° d Monocero |
| 14 | 12 14 a.m. | Weston-super-Mare. | =1st mag.* ..... | Orange..... | 1·5 second ... | α = From 123° + to 104 + |
| 14 | 12 24 30 a.m. | Hawkhurst (Kent). | =2nd mag.* ..... | Orange yellow | 1 second ..... | From β Tria to c Muscæ |
| 14 | 12 30 40 a.m. | Ibid ..... | Bright as Jupiter... | White ..... | 1 second ..... | Appeared at Ursæ Majori |
| 14 | 12 33 40 a.m. | Ibid ..... | =2nd mag.* ..... | Yellow ..... | 1 second ..... | From γ Tria to β Androm |
| 14 | 12 34 30 a.m. | Ibid ..... | 4×Venus ..... | Emerald green | 2 seconds..... | Disappeared p. θ Leonis. |
| 14 | 12 36 a.m. | Wisbeach..... | =3rd mag.* ..... | Yellow ..... | Rapid ..... | From near μ L Majoris, bet ν, d Leonis noris. |
| 14 | 12 37 50 a.m. | Hawkhurst (Kent). | =1st mag.*..... | White ..... | 1·2 second ... | From ε Ursæ joris to ½ ( Camelopardi. |
| 14 | 12 39 a.m. | Ibid ..... | =Sirius ..... | Yellow ..... | 1·4 second ... | From k Lyncis Leonis Minor |
| 14 | 12 42 20 a.m. | Ibid ..... | As bright as Jupiter | Orange yellow | 1 second ..... | Appeared at γ onis. |
| 14 | 12 44 a.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·5 second ... | From ½ (ε, ζ onis to β Eri |
| 14 | 12 48 50 a.m. | Ibid ..... | Brighter than a 1st mag.* | White ..... | 1·3 second ... | From e Cephe g Honorum. |
| 14 | 12 49 30 a.m. | Ibid ..... | As bright as Jupiter | Greenish white | 1·4 second ... | From ε Ursæ joris to γ Ce |
| 14 | 12 52 20 a.m. | Ibid ..... | As bright as Jupiter | White ..... | 1·3 second ... | From ζ Gemin to $\gamma_1$ Orion |
| 14 | 1 0 a.m. | Ibid ..... | Brighter than a 1st mag.* | Orange yellow | 1·5 second ... | First appeared a Draconis. |
| 14 | 4 34 2 a.m. | Streatham, near London. | =Regulus ..... | Yellowish white. | ..... | α = From 142° + 3 to 146 + |
| 14 | 4 34 15 a.m. | Ibid ..... | =Altair ..... | Yellow ..... | ..... | From 124° + to 98 + |

| ...rances; Train, if any, ...nd its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| ...a streak for 2 seconds | ..... | ..... | ..... | A. S. Herschel & H.T.Humphreys. |
| ...a streak for 2 seconds, ...ich appeared to be ...ided longitudinally. | ..... | ..... | ..... | Id. |
| ..... | 15° ..... | E. to W. ..... | ..... | Id. |
| ...a streak for 3 seconds, ...ich faded from the ...ds towards the centre. | ..... | ..... | Very good observation.. | Id. |
| ..... | ..... | ..... | ..... | W. H. Wood. |
| ...a broad yellow streak ...2 seconds. | ..... | ..... | ..... | A. S. Herschel & H.T.Humphreys. |
| ..... | ..... | ..... | ..... | W. H. Wood. |
| ...w gradually less; left ...a streak. | ..... | ..... | ..... | A. S. Herschel & H.T.Humphreys. |
| ..... | 5°..... | Directed from $\kappa$ Leonis. | ..... | Id. |
| ...w gradually less; left ...a train. | ..... | ..... | ..... | Id. |
| ...ised a strong light in ...e sky like lightning; ...reak red; duration 2 ...conds. | 6°..... | Directed from $\zeta$ Leonis.. | ..... | Id. |
| ..... | 15° ..... | ..... | ..... | S. H. Miller. |
| ...a streak for 2 seconds | ..... | ..... | ..... | A. S. Herschel & H. T. Humphreys. |
| ...train or sparks; grew ...adually less. | ..... | ..... | Good observation ..... | Id. |
| ..... | 3°..... | Directed from $\zeta$ Leonis | ..... | Id. |
| ..... | ..... | ..... | ..... | Id. |
| ..... | ..... | ..... | Exact observation ..... | Id. |
| ...a broad very bright ...streak for five seconds. | ..... | ..... | ..... | Id. |
| ...a streak for 3 seconds | ..... | ..... | ..... | Id. |
| ...no streak; grew gra...dually less. | 10° ..... | Directed from $\beta$ Aurigæ | ..... | Id. |
| ...no train ..... | ..... | ..... | ..... | S. B. Kincaid. |
| ...no train ..... | ..... | ..... | ..... | Id. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, a Altitude an Azimuth. |
|---|---|---|---|---|---|---|
| 1865. Nov. 14 | h m 5 30 a.m. until sunrise. | Weston-super-Mare. | ..... | ..... | ..... | ..... |
| 15 | 8 38 + p.m. | Greenwich Park | =2nd mag.* ..... | Bluish white... | 1 second ..... | From a point ab 3° above β rigæ. Di peared a litt the S. of θ rigæ. |
| 15 | 8 54 p.m. | West Hendon, Sunderland. | =3rd mag.* ..... | ..... | ..... | Vanished 2° a below and to left of ψ Aqu |
| 15 | About 10 40 p.m. | Wimbledon (Surrey). | Nearly = Sirius ... | Bluish white... | 3 seconds ... | Passed about above Pol Course a= From 152° + 5 to 337 + 4 |
| 17 | 7 47 p.m. | Primrose Hill (London). | =2nd mag.* ..... | White ..... | 0·5 second ... | From σ Vulpec to 2½° below Aquilæ. |
| 17 | 8 30 p.m. | Greenwich ..... | =1st mag.* ..... | Bluish white.. | Less than 1 sec. | Passed across Aquarii from t direction of Equulei. |
| 18 | About 4 30 p.m. | Wimbledon (Surrey). | Nearly as bright as Jupiter. | ..... | ..... | Passed somew below Polaris. |
| 18 | 4 30 p.m. | Cambridge ..... | A brilliant meteor.. | ..... | 2·5 seconds ... | In the western p tion of the h vens. |
| 18 | 5 20 p.m. | Royston ..... | A conspicuous meteor. | Yellowish white. | 2 seconds ... | From a little W. η, to 2½° belo γ Ursæ M joris. |
| 18 | 6 4 30 p.m. | Blackheath ..... | =3rd mag.* ..... | White ..... | 1 second ..... | Fell vertically p κ Draconis t wards ψ Ur Majoris. |

| rance; Train, if any, nd its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| ..... | ..... | ..... | Orange-coloured shooting-stars = 1st and 2nd mag. stars; some brighter. Fell vertically from an altitude of about 25°, N. or N.W., at the rate of twelve per hour. Sky clear; radiant $\mu$ Leonis. | Communicated by W. H. Wood. |
| o train ..... | ..... | Curved ..... | ..... | Thomas Wright. |
| ..... | ..... | ..... | ..... | T.W. Backhouse. |
| a conspicuous train phosphorescent light. | ..... | From E.N.E. to W.S.W. | ..... | F. C. Penrose. |
| a train on its whole rse. | ..... | Inclined a little downwards to the right. | ..... | T. Crumplen. |
| no train ..... | ..... | Inclined at an angle of 45°. | ..... | W. C. Nash. |
| meteor divided near e end of its course into o bright objects, one llowing the other. | ..... | ..... | ..... | Communicated by F. C. Penrose. |
| a train of light of a le green colour. | ..... | ..... | Very luminous; seen in strong twilight. This observer saw the meteor of Nov. 13th, $5^h\ 42^m$ p.m. | Communicated by T. Crumplen. |
| a rocket with a short il. | ..... | Horizontal ..... | ..... | Id. |
| no train ..... | 5°..... | Perpendicular ..... | Centre of track opposite $\kappa$ Draconis. | Thomas Wright. |

UNIVERSITY CALIFORNIA

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, Altitude a Azimuth |
|---|---|---|---|---|---|---|
| 1865. Nov. 18 | h m s 6 14 30 p.m. | Blackheath ..... | =3rd mag.* ..... | White ..... | 3 seconds ... | Passed midw tween $\mu$ Lyræ towa Draconis. |
| 18 | 6 59 30+ p.m. | Ibid ..... | =2nd mag.* ..... | Bluish ..... | 2 seconds..... | From $\gamma$ Cygni point nea Cygni. |
| 18 | 9 23 p.m. | Greenwich ..... | =2nd mag.* ..... | Blue ..... | 3 seconds ... | From the dir of Capella wards $\alpha$ Ori |
| 18 | 9 45 ± p.m. | Granchester (Cambridge). | A bright meteor... | ..... | ..... | Course paral and just $\beta$, $\gamma$ Ursæ joris. |
| 18 | 9 45 ± p.m. | Ibid ..... | A bright meteor... | ..... | ..... | Near $\epsilon$ Ursæ joris. |
| 21 | Evening ... | Finchley, near London. | Three times larger and brighter than Venus at its brightest. | ..... | ..... | Passed do overhead. |
| 21 | 6 0 p.m. | Oundle (Notts)... | Unusually brilliant meteor. | ..... | About 4 secs.. | From $\frac{1}{2}$° be Ceti to $\frac{1}{2}$° $\delta$ Aquarii; mencing t east of and disappe some dis below $\xi$ C corni. |
| 21 | 6 0 p.m. | Wisbeach (Cambridgeshire). | Twice the apparent size of Jupiter. | Meteor blue; tail white. | ..... | Appeared with of the Pl [? if $\psi$ Aqu and moved the sky full |
| 21 | 6 0 p.m. | Norwich ..... | Very large meteor.. | Colours vivid; changing. | At least 2 or 3 seconds. | Started nea zenith, and appeared S. |
| 21 | A few minutes past 6 o'clock. | Harpenden, St. Albans (Herts). | ..... | ..... | ..... | First appeared at altitude a 58°. Di peared ca southern m dian. |
| 21 | A few minutes after 6 p.m. | Near Liverpool; Lat. N. 53° 24′ 39″, Long. W. 2° 59′ 30″. | Large meteor ..... | ..... | Moved slowly. | The meteor first seen S.E. altitude 25° or 30°, went out at same a S.W. |
| 21 | 6 5 p.m. | New Brighton, Liverpool. | Large and bright... | ..... | ..... | Like a Roma die ball. |

| arance; Train, if any, and its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| a faint train..... | 10° ..... | Inclined ..... | ..... | Thomas Wright. |
| a faint train..... | 15° ..... | Slightly inclined from perpendicular. | ..... | Id. |
| a faint train..... | 20° ..... | Inclined ..... | ..... | Thomas Wright; Arthur Harding. |
| no train ..... | 10° ..... | Inclined ..... | ..... | W. H. Hudson. |
| sh..... | No path ... | ..... | ..... | Id. |
| ..... | ..... | N.E. to S.W. ..... | Cloudy and rain falling; stars invisible; the meteor was above the clouds and shone through them. | J. H. Heal. |
| wed by a tail some 6° 8° long, but did not rst. | ..... | ..... | Approximate position taken the following evening. | Communicated by Hugh Weightman. |
| ape like a blunt spear-ad, drawing a tail of hite light, and sparks hind it. | 30° ..... | Inclined 15° from horizontal. | ..... | The 'Times,' Nov. 24th. |
| ll of intensely brilliant ght, leaving behind it brilliant arch or bow light. | About 30°.. | Descending in S.W. ... | ..... | Norwich 'Mercury.' |
| r gradually increasing dazzling brightness, suddenly changed to e red glow of dull ignition, and finally disappeared. | ..... | E. to W. ..... | Sky calm and clear. The meteor cast a shadow of the observer on the ground. | The 'Times,' Robert Lynn. |
| ..... | ..... | ..... | ..... | Mathew M. Brown. |
| ared only from a fire-ork in its perpendicu-r fall. | ..... | ..... | ..... | H. Bower. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, or Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1865. Nov.21 | h m s 6 5 p.m | Near Cranford (Middlesex); N. lat. 51° 29′ 40″, W. long. 0m 21s. | Three times as bright as Venus at its brightest. | Brilliant bluish white; tail reddish. | Slow speed; duration about 10 seconds. | First appeared at an altitude 40° above eastern hor Passed to th of, and thin the stellation Ca peia, almost tically over and disapp about 25° a the horizon W. |
| 21 | 6 5 p.m. | Nottingham Park (Nottingham). | Large meteor ..... | ..... | ..... | ..... |
| 21 | 6 5 p.m. | Near Bedford ... | Large fireball ..... | ..... | ..... | Appeared in E.N.E. or E. disappeared |
| 21 | 6 5 p.m. | Weston-super-Mare. | Very large ..... | Brilliant blue.. | ..... | Appeared at an al tude of about or 40° in the and disappe N.E. |
| 21 | 6 5 or 6 6 p.m. | Oxford ..... | Larger and brighter than Venus appears. | Blue ..... | ..... | In the S., not mo degrees above t horizon. |
| 21 | 6 6 p.m. | Northolt (Harrow). | Large meteor ..... | ..... | ..... | Traversed the sk and disappear on the horiz due W. |
| 21 | 6 8 30 p.m. | Colebyfield, Wimbledon (Surrey). | 6′ of arc in width; ½ diameter of the moon. | White or greenish, shading into blue. No change of colour during its appearance. | Speed 15° per second. | From an altitude 76° 5′, a li northward of t zenith, to a po in R. A. 18h 0 N. Decl. 4 about 8° N.W. α Lyrae. T positions m sured with equatorial te scope soon a disappearance |
| 21 | 6 9 p.m. | Shoeburyness (Essex). | Very large meteor.. | ..... | About 7 secs... | Appeared in the nith, and pa at an altitude 70° behind a b band of clou reappearing i mediately, a disappeared an altitude of behind a de pack of clouds |

| arance; Train, if any, and its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| a Roman-candle ball, lowed by a tail from ° to 3° in length. ie throwing off of the itter forming the tail uld be distinguished. isappeared without rsting. | ..... | E. to W. ..... | Sky hazy, and principal stars, with the exception of those of Cassiopeia, obscured. No noise accompanied or followed its appearance. | WarrenDelaRue. |
| ented the same appearance as at Cranford. | ..... | ..... | ..... | R. A. Tucker. |
| bular ..... | ..... | ..... | Very brilliant ..... | Communicated by T. Crumplen. |
| a train 8° in length... | 30° ..... | Inclined downwards towards the left from perpendicular. | Very rough positions ... | Communicated by W. H. Wood. |
| ppeared almost instantly. | Almost stationary. | ..... | ..... | S. S. Burnet. |
| e a ball of fire ..... | ..... | ..... | Light of meteor very startling; lightning at 8 p.m. | T. H. Gordon. |
| r-shaped, surrounded by an edge of purplish ight, and by a halo aused by thin cloud, which hid the tail. Disappeared suddenly without any previous loss of light. | ..... | Due E. to W. ..... | Cast a light as bright, but colder in colour than moonlight. A loud report like that of a cannon some miles off was heard about 2m 20s after the meteor disappeared. | F. C. Penrose. |
| sembled a comet, being followed by a train. | ..... | S. to N., with a tendency to W. | ..... | The 'Times,' Nov. 24th. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, or Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1865. Nov. 21 | h m s 6 9 p.m. | Danbury Hill (Essex). | Apparent diameter $\frac{1}{2}°$. | Bright yellow | ..... | From within 2° of the zenith; descended in a south-west direction; disappearing behind black cloud in the W. horizon. |
| 21 | 6 10 p.m. | Copse Hill, Wimbledon. | At least twice as bright as any planet. | Yellower than Venus. | ..... | ..... |
| 21 | About 6 15 p.m. | Observatory, Cambridge. | Two or three times brighter than Venus. | Flame-coloured. | Duration not less than 4 or 5 secs. | From $\beta$ Aquæ across $\delta$ Aquæ to $\theta$ Aquilæ. |
| 21 | About 6 15 p.m. | Hawkhurst (Kent). | $\frac{1}{3}$ diameter of full moon. | White, with red tail. | Very short duration. | From an altitude of 55°, between magnetic and N.; shot downwards towards the W.N.W. horizon. |
| 21 | 7 11 45 p.m. | Greenwich ..... | = 1st mag.* ..... | Blue ..... | 2 seconds..... | Passed between $\alpha$ and $\epsilon$ Delphini and disappeared a little below $\alpha$ Aquilæ. |
| 21 | 8 48 p.m. | Weston-super-Mare. | = 4th mag.* ..... | Dark-coloured | 0·5 second ... | $\alpha$ = [illegible] From 39° + [illegible] to 28 [illegible] |
| 21 | 10 1 p.m. | Blackheath (Kent). | = 2nd mag.* ..... | Bluish white.. | 1 second ..... | Appeared near [illegible] passed by $\zeta$, and disappeared a little above Orionis. |
| 22 | 7 17 p.m. | Weston-super-Mare. | = 1st mag.* ..... | Yellow ..... | 2 seconds ... | $\alpha$ = [illegible] From 210° + [illegible] to 228 [illegible] |
| 22 | 11 11 15 p.m. | Greenwich ..... | = 2nd mag.* ..... | Blue ..... | 1 second ... | From $\tau$ towards Cygni. |
| 24 | 6 39 p.m. | Ladywell, Lewisham. | = 3rd mag.* ..... | Bluish white... | $\frac{1}{2}$ second ..... | From the direction of $\alpha$ Herculis disappeared near $\gamma$ Draconis. |
| 24 | 6 45 p.m. | Ibid ..... | = 2nd mag.* ..... | Blue ..... | 1 second ..... | Disappeared a little below $\beta$ Aurigæ |
| 24 | 8 20 p.m. | Ibid ..... | Twice as bright as Venus. | Yellow ..... | 4 seconds..... | From the direction of $\alpha$ Lyncis passed across Ursæ Majoris and a few degrees beyond. |
| 24 | 8 37 p.m. | Greenwich ..... | = 3rd mag.* ..... | Blue ..... | 1 second ..... | From the direction of the Pleiades towards $\zeta$ Tauri |

| ...arance; Train, if any, and its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| ...l of fire, followed by ...al of the same width ... in length. The b...dy ...ght yellow; the tail ...en, blue, and dusty ...low. | ..... | ..... | Cast a glaring light; the streak remained visible a few seconds after the meteor had disappeared. Air very clear, and the stars very bright. | The 'Standard,' Nov. 23rd. |
| ...a track behind it after ...e nucleus disappeared. | ..... | E. to W., perpendicularly down. | Cast a light on the road like the flash of carriage lamps. | J. Ludlow. |
| ...wed by a long ...ickering tail. Remained invisible behind a cloud whilst ...or 5 seconds were ...ounted, and then reappeared again. | ..... | ..... | The light was sufficient to have read a watch. | H. Todd. |
| ...ll of fire, followed by ...long tail. | ..... | ..... | Seen through a break in the clouds; shortly followed by a hail-storm. Light sufficient to pick up a pin. | Communicated by A. S. Herschel. |
| ...a faint train..... | 10° ..... | Inclined ..... | Descended with a waving motion. | Thomas Wright. |
| ..... | ..... | ..... | ..... | W. H. Wood. |
| ...no train ..... | 6°..... | Nearly perpendicular ... | ..... | Thomas Wright. |
| ...a train 10° in length. The meteor increased from a 3rd to a 1st magnitude star. | ..... | ..... | ..... | W. H. Wood. |
| ...no train ..... | 10° ..... | Inclined ..... | ..... | Arthur Harding. |
| ...no train ..... | 6° ..... | Inclined ..... | ..... | F. Trapaud. |
| ...a train ..... | 10° ..... | Inclined; directed from $\epsilon$ Persei. | ..... | Id. |
| ...a train ..... | 30° ..... | Inclined ..... | ..... | Id. |
| ...t no train ..... | 7°..... | Inclined ..... | ..... | Arthur Harding. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, Altitude a Azimuth. |
|---|---|---|---|---|---|---|
| 1865. Nov.24 | h m s 9 9 42 p.m. | Observatory, Cambridge. | Large meteor ..... | ..... | ..... | Crossed the S. dian at an alt of about 25° |
| 24 | 9 13 or 9 14 p.m. | Cheltenham ... | 2nd or 3rd mag. at first; before reaching head of Orion broke out to size of Jupiter, but speedily extinguished. | ..... | ..... | Began somew between α a Tauri ; peared in he Orion, or pe between α a Orionis. |
| 26 | 7 25 p.m. | West Hendon, Sunderland. | =1st mag.* ..... | Orange colour | ..... | Passed ζ Herc |
| 26 | 8 30 p.m. | Lewisham ..... | =1st mag.* ..... | Yellow ..... | 1 second ..... | From a point way betwee pella and β rigæ to a po little below Pleiades. |
| 27 | 4 40 a.m. | Weston-super-Mare. | =1st mag.* ..... | Yellow ..... | 0·5 second ... | From λ to π onis. |
| 28 | 3 7 a.m. | Cromer (Norfolk) | As bright as Venus.. | White, then yellow. | 1·5 second ... | From θ Draco φ Herculis. |
| 28 | 3 25 a.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·5 second ... | From 54 La Minoris to Leonis, and beyond. |
| 28 | 3 29 a.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·6 second ... | From ν Ursæ noris to g L conis ; 5° be and after. |
| 28 | 3 35 a.m. | Ibid ..... | =3rd mag.* ..... | Yellow ..... | 0·5 second ... | From b to a Ca Venaticorum, onwards a again. |
| 28 | 4 13 a.m. | Ibid ..... | =2nd mag.* ..... | Yellow, then orange-red. | 2·2 seconds ... | From ½ (Proc to ½ (B, Hydræ. |
| Dec. 2 | 9 47 30 p.m. | Royal Observatory, Greenwich. | =1st mag.* ..... | Bright blue ... | 1 second ..... | From the direct of α Cassiop towards γ gasi. |
| 7 | Evening ... | Blaenafon, Pontypool. | Large and very bright. | Crimson-red at the last. | ..... | From altit about 40°, N. to a some less altitu N.W. |
| 7 | 7 30 p.m. | Vannes (France) | Size of the full moon. | Head and train bluish white; sparks red. | Slow speed ... | From α Andro to δ Arietis. |
| 8 | 10 55 p.m. | Hawkhurst (Kent). | =3rd mag.* ..... | Yellow ..... | 1·1 second ... | From υ to λ G norum. |
| 8 | 10 55 30 p.m. | Ibid ..... | =2nd mag.* ..... | Red and white | 0·8 second ... | From Polaris t Draconis. |

| earance; Train, if any, and its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| ing like a Roman-adle ball. | ..... | Nearly horizontal, perhaps slightly downwards; E. to W. | Observed between shutters whilst waiting for a transit. | A. Graham. |
| ..... | ..... | Inclined a little to left of vertical. | Oblique vision; details only approximate. | T. W. Webb. |
| ..... | ..... | Vertically down ..... | ..... | T. W. Backhouse. |
| a fine train ..... | 30° ..... | Inclined ..... | ..... | F. Trapaud. |
| a streak 8° in ngth. | ..... | ..... | ..... | W. H. Wood. |
| ular, no train or sparks, rew gradually less. | ..... | ..... | ..... | A. S. Herschel. |
| a faint train for ½ a econd. | ..... | ..... | ..... | Id. |
| a bright streak for 2½ econds, which faded from the ends towards the centre. | ..... | ..... | ..... | Id. |
| a faint streak for ½ a econd. | ..... | ..... | In one hour, ten meteors seen. Clear sky; no moon; one observer. | Id. |
| train or sparks; grew gradually less. | ..... | ..... | At $10^h\ 13^m$ and $10^h\ 17^m$ a.m., very bright mock-suns; the first on the left, the second on the right of the sun. | Id. |
| no train ..... | 25° ..... | Inclined ..... | ..... | Arthur Harding. |
| ake up into numerous mall fragments. | ..... | ..... | Of the same size and appearance as that of the 14th November. | J. J. Jones. |
| und or elongated, with a very luminous envelope and train; broke into a mass of sparks. | ..... | W. to E. ..... | $3^m\ 30^s$ afterwards a report was heard which shook the houses. (See Appendix II.) | Comte de Limen, and M. Garnache. |
| eft no train ..... | ..... | ..... | At $11^h\ 6^m$ the sky became overcast. | A. S. Herschel. |
| lo train or sparks ..... | ..... | ..... | Four meteors in fifteen minutes; sky clear; no moon; one observer. | Id. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, or Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1865. Dec. 8 | h m s 11 4 p.m. | Hawkhurst (Kent). | =3rd mag.* ..... | White ..... | 0·9 second ... | From $\pi$ Ursæ M joris to $p$ Ca lopardi. |
| 9 | 8 5 p.m. | West Hendon (Sunderland). | =2nd mag.* ..... | Orange colour | ..... | Near $d$ and $\mu$ Pe |
| 9 | 8 30 p.m. (local time.) | Charleston, U. S. | ..... | ..... | ..... | ..... |
| 11 | 6 4 57 p.m. | Royal Observatory, Greenwich. | =Aldebaran ..... | Yellow ..... | 3 seconds..... | From a point below and S. $\alpha$ Andromed passed betw $\beta$ and $\tau$ Peg and disappe a few deg above $\epsilon$ gasi. |
| 11 | 6 17 36 p.m. | Ibid ..... | =2nd mag.* ..... | Bluish ..... | 2 seconds..... | From a point ab 1° above Pola disappeared ab 2° above $\tau$ D conis. |
| 11 | 6 20 42 p.m. | Ibid ..... | =1st mag.* ..... | Yellow ..... | 3 secs.; very slow motion. | From a point ab 3° above $\alpha$ D conis; dis peared about above $\epsilon$ U Majoris. |
| 11 | 6 25 49 p.m. | Ibid ..... | Twice as bright as Jupiter. | Bright yellow | 5 seconds..... | From about 3° of $\tau$ Aqua past $\vartheta$ Aqu and disapp about 8° W. Fomalhaut. |
| 11 | 6 28 2 p.m. | Ibid ..... | Twice as bright as Jupiter. | Bright yellow | 5 secs.; very slow motion. | From about 1° b low $\beta$ Cyg passing W. of Aquilæ, and d appeared 10 b low and E. of Antinoï. |
| 11 | 7 0 15 p.m. | Ibid ..... | =3rd mag.* ..... | Bluish white... | 0·3 second ... | From a point few degrees s the Pleiades point a few greees below Arietis. |
| 11 | 7 4 58 p.m. | Ibid ..... | =3rd mag.* ..... | Bluish ..... | Momentary duration. | From about above to ab 3° below Cygni. |

| ırance; Train, if any, ınd its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| ı slight train ..... | ..... | ..... | Moon just rising; meteors scarce. On the previous and following nights the sky was overcast. | A. S. Herschel. |
| ..... | ..... | ..... | ..... | T. W. Backhouse. |
| ..... | ..... | ..... | A meteoric flash, followed by an explosion at an interval of about one minute. (See Appendix II.) | American Journ. of Science, Mar. 1866. |
| a fine train for 1 sec.. | 36° ..... | Inclined ..... | Very wavy motion ..... | Thomas Wright. |
| ıo train ..... | 17° ..... | Almost horizontal ..... | ..... | Id. |
| no train ..... | 15° ..... | Inclined ..... | ..... | Id. |
| ı no train ..... | 15° ..... | Almost perpendicular... | This was a most splendid meteor. | Id. |
| ı a splendid yellow ıain for 3 seconds after ıe disappearance of the ıeteor. | 40° ..... | Inclined ..... | ..... | Id. |
| ı no train ..... | 7°..... | Nearly horizontal ..... | Clouds rising in the E.... | W. C. Nash. |
| ft no train ..... | 6° ..... | Inclined ..... | Cloudy after this time throughout the remainder of the night. | Thomas Wright. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position. or Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1865. Dec. 13 | h m s 7 20 p.m. | West Hendon (Sunderland). | Brighter than Sirius | Yellow ..... | ..... | Vanished near Draconis. |
| 14 | 8 9 6 p.m. | Royal Observatory, Greenwich. | =2nd mag.* ..... | Blue ..... | 2 seconds..... | From a point a little to the of $\rho$ Ursæ joris; pas about 2° of $i$ Ursæ joris, and dis peared about above Majoris. |
| 14 | 8 21 53 p.m. | Ibid ..... | =3rd mag.* ..... | Blue ..... | 1 second ..... | From the direct of E Lyn disappeared little above Lyncis. |
| 14 | 8 37 40 p.m. | Ibid ..... | =3rd mag.* ..... | Blue ..... | Momentary ... | Passed parallel a line join and $\theta$ U Majoris, about 2° ab those stars. |
| 14 | 8 44 46 p.m. | Ibid ..... | =2nd mag.* ..... | Blue ..... | 2 seconds..... | From $\theta$ Orionis wards $\alpha$ Lepo |
| 14 | 9 6 28 p.m. | Ibid ..... | =3rd mag.* ..... | Blue ..... | Rapid motion | Passed parallel line joining and $p$ Cam pardi. |
| 14 | 9 38 15 p.m. | Ibid ..... | =3rd mag.* ..... | Bluish ..... | Momentary ... | From the di tion of $\beta$ C siopeiæ, pas Cassiopeiæ |
| 14 | 10 15 p.m. | Ibid ..... | =2nd mag.* ..... | Bluish white... | More than 1 second. | From a point 2° of $\epsilon$ Geminor passed betwee and $\delta$ Gem rum, and dis peared 3° be the latter st |
| 14 | 10 17 p.m. | Ibid ..... | =3rd mag.* ..... | Bluish ..... | Momentary ... | From a point 1° above C past that towards the horizon. |
| 14 | 10 19 p.m. | Ibid ..... | Twice as bright as a 1st mag.*. | Blue ..... | 5 seconds..... | From a point 2° W. of $\epsilon$ Lac moved paral a line joinin and $\epsilon$ Cygni the west of t stars), to a 10° beyond latter star. |

| ance; Train, if any, d its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| slight train before nished. | ..... | ..... | ..... | T. W. Backhouse. |
| faint train..... | 20° ..... | Latter part of course curved.  | ..... | Arthur Harding. |
| o train ..... | 7°..... | Inclined at an angle of 45°. | Slow in motion ..... | Arthur Harding and Thomas Wright. |
| o train ..... | 5°..... | Inclined at an angle of about 10° from horizontal. | ..... | Arthur Harding. |
| o train ..... | 10° ..... | Inclined ..... | Very slow motion ..... | Id. |
| o train ..... | 4°..... | Inclined ..... | ..... | Id. |
| o train ..... | 4°..... | ..... | ..... | Thomas Wright. |
| a faint train..... | 12° ..... | Almost perpendicular... | ..... | Arthur Harding and Thomas Wright. |
| o train ..... | 3°..... | Inclined ..... | ..... | Thomas Wright. |
| a train ..... | 35° ..... | Almost perpendicular... | ..... | Arthur Harding. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, or Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1865. | h m s | | | | | |
| Dec. 14 | 10 56 p.m. | Hawkhurst (Kent). | =2nd mag.* ..... | White ..... | 0·5 second ... | From a Tauri to T Cephei. |
| 14 | 11 5 p.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·5 second ... | Disappeared at Cancri. Co halfway fro Geminorum. |
| 14 | 11 9 p.m. | Ibid ..... | =1st mag.* ..... | White ..... | 0·5 second ... | Appeared mid between 3 Le and 54 Le Minoris. |
| 20 | 6 56 30 p.m. | Blackheath (Kent). | =1st mag.* ..... | Bluish ..... | 2 seconds ... | From a point ab 4° above Pegasi; was between t star and Pegasi, and appeared ab 3° above \ gasi. |
| 21 | 7 55 p.m. | Weston-super-Mare. | =3rd mag.* ..... | Blue ..... | 2 seconds ... | From a poi R. A. 81 Decl. 26° Tauri. |
| 24 | 8 30 to 9 30 p.m. | Ibid ..... | ..... | ..... | ..... | ..... |
| 24 | 11 52 p.m. | Hawkhurst (Kent). | =2nd mag.* ..... | White ..... | 0·7 second ... | Disappeared at Monocerotis. |
| 25 | 7 8 p.m. | Weston-super-Mare. | =2nd mag.* ..... | White ..... | 1 second ..... | From α Arietis t Ceti. |
| 25 | 7 34 p.m. | Ibid .... ..... | =Venus ..... | Yellow ..... | 2·5 seconds ... | α = From 307° + 4 to 292 3 |
| 27 | 8 20 to 9 20 p.m. | Ibid ..... | ..... | ..... | ..... | ..... |
| 1866. | | | | | | |
| Jan. 6 | 6 5 p.m. | Ibid ..... | =2nd mag.* ..... | Red ..... | 1·5 second ... | From τ Pegasi t Cygni. |
| 6 | 8 28 p.m. | Hawkhurst (Kent). | =2nd mag.* ..... | White ..... | 0·5 second ... | From λ Tauri τ Custodis. |
| 6 | 8 44 p.m. | Ibid ..... | =3rd mag.* ..... | Yellow ..... | 1·3 second ... | From τ Gemin to 66 Aurigæ. |
| 6 | 8 48 p.m. | Royal Observatory, Greenwich. | =3rd mag.* ..... | Blue ..... | Momentary ... | From the dir tion of ξ C siopeiæ wards α And medæ. |
| 6 | 8 54 p.m. | Ibid ..... | =2nd mag.* ..... | Blue ..... | 1 second ..... | From the dir tion of Cygni towards Cygni. |

| ...carance; Train, if any, and its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| ...rain or sparks ..... | ..... | ..... | ..... | A. S. Herschel. |
| ...rain or sparks ..... | ..... | ..... | ..... | Id. |
| ...tationary flash; no ...reak left. | ..... | ..... | Three meteors in thirty minutes: clear sky; no moon; one observer. | Id. |
| ...o train ..... | 10° ..... | ..... | Foggy ..... | Thomas Wright. |
| ..... | ..... | ..... | ..... | W. H. Wood. |
| ..... | ..... | ..... | Sky fine and clear; in one hour no meteors seen. | Id. |
| ...rain or sparks ..... | 8° ..... | Directed from $\gamma$ Geminorum. | One meteor only seen in one hour. Sky generally clear (occasionally hazy); no moon; one observer. | A. S. Herschel. |
| ... ..... | ..... | ..... | ..... | W. H. Wood. |
| ...-shaped; inner border ...ed, thus— ...parkled; left a red ...reak 8° long for 4 ...econds. | ..... | ..... | ..... | Id. |
| ..... | ..... | ..... | Sky fine and clear; in one hour no meteors seen. | Id. |
| ..... | ..... | ..... | Slow speed ..... | Id. |
| ...rain or sparks ..... | ..... | ..... | ..... | A. S. Herschel. |
| ...rain or sparks; grew ...radually less. | ..... | ..... | Four meteors in one hour: clear sky; no moon; one observer. | Id. |
| ...train ..... | 10° ..... | ..... | ..... | Arthur Harding. |
| ...train ..... | 10° ..... | Inclined ..... | ..... | Id. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, or Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1866. | h m | | | | | |
| Jan. 6 | 9 59 p.m. | Royal Observatory, Greenwich. | Twice as great as Jupiter. | Brilliant blue.. | 5 seconds ... | From a p about 1° a and N. of Cygni; Cas peared a f degrees N. o Pegasi. |
| 6 | 10 4 p.m. | West Hendon, Sunderland. | Far brighter than Venus appears at its brightest. | ..... | Scarcely 1 sec., very fast. | Passed very ne Bridani, and appeared wi 1° or 2° of π |
| 6 | 10 5 p.m. | Wisbeach (Cambridgeshire). | Twice as bright as Venus. | Bright blue ... | 4 seconds ... | No exact note position preser |
| 7 | 7 43 p.m. | West Hendon, Sunderland. | =3rd mag.* ..... | Orange colour | ..... | Vanished about to the right o Pegasi. |
| 8 | 5 54 p.m. | Blackheath (Kent). | =3rd mag.* ..... | Bluish white... | Less than half a second. | From the direct of α, passed tween ζ and Orionis. |
| 8 | 8 15 to 8 35 p.m. | Hawkhurst (Kent). | ..... | ..... | ..... | ..... |
| 8 | 9 22 p.m. | Blackheath (Kent). | =2nd mag.* ..... | Bluish ..... | 3 seconds..... | From a point 3° 4° N. of ε C siopeiæ; fell t wards δ Cephe |

| rance; Train, if any, ıd its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| ine yellow train for 20° conds. | 20° | | | Thomas Wright. |
| ed in brightness first to last; peared suddenly. a bright sparkling , and left a luminous streak from R. A. 2m S., Decl. 11°, R. A. 2h 45m, S. l. 14°, for a third of a minute, at t, if not longer, gh very faint. | | | Sky cloudless | T. W. Backhouse. |
| train for 10 seconds | | Nearly perpendicular | This was a remarkable shooting-star. Its appearance is represented very nearly in the sketch. It showed three distinct stages: the central part disappeared first, then the head; and the train, in the shape I have represented, brightened up. | S. H. Miller. |
| ed rather gradually | | Fell vertically down | | T. W. Backhouse. |
| o train | 6° | Inclined | | Thomas Wright. |
| | | | Four small meteors seen in 20 minutes. Sky bright and clear; no moon; one observer. On the nights of the 9th and 10th the sky was overcast. | A. S. Herschel. |
| o train | 20° | Perpendicular | | Thomas Wright. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, & Altitude a... Azimuth. |
|---|---|---|---|---|---|---|
| 1866. | h m | | | | | |
| Jan. 8 | 9 46 p.m. | Blackheath ..... | =3rd mag.* ..... | White ..... | 1 second ..... | From a point little above Ursæ Minoris passed τ U Minoris, wards θ D conis. |
| 8 | 10 5 p.m. | Ibid ..... | =2nd mag.* ..... | Bluish white... | 2 seconds ... | From about above and of η Orion disappeared few degrees low and E. of Orionis. |
| 9 | Evening ... | Sunbury (Middlesex). | Large meteor ..... | ..... | Considerable velocity. | Across the constellation of Orion |
| 9 | 9 14 p.m. | Blackheath ..... | =2nd mag.* ..... | Bluish white... | Half a second.. | From a point little above Sir disappeared ab 1° above and yond β Canis joris. |
| 9 | 9 35 p.m. | Ibid ..... | =2nd mag.* ..... | Bluish white.. | 2 seconds..... | From about above and S α Pegasi; d appeared ab 5° below star. |
| 9 | 9 38 p.m. | Ibid ..... | =1st mag.* ..... | White ..... | 1 second ..... | From a little e; passed way betwe and g, and appeared a below a certæ. |
| 11 | Evening ... | Alkmonton (Derbyshire). | Much brighter than the fixed stars. | ..... | Very rapid speed. | Passed abov house, rently at great altitud |
| 11 | 9 52 p.m. | Hay (S. Wales). | At first =2nd mag.*, afterwards twice as bright as Sirius, but looking much larger; diameter about 10′. | Deep yellow; train whiter in colour than the head. | 4 or 5 seconds | From altitud bout 15°, E in Monoce the mete passed ex across α Ori and proce as far as head of A when it di peared bel The termina of its course seen. |

| earance; Train, if any, and its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| no train ..... | 6°..... | Inclined ..... | ..... | Thomas Wright. |
| no train ..... | 5°..... | Perpendicular ..... | ..... | Id. |
| it into fragments, hich proceeded on-ards in the same irection, becoming nner. Left no ain. | ..... | ..... | ..... | J. Gale. |
| no train ..... | 6°..... | Slightly inclined ..... | ..... | Thomas Wright. |
| no train ..... | 10° ..... | Perpendicular ..... | Seen through trees ..... | Id. |
| no train ..... | 8°..... | Curved ..... | ..... | Id. |
| a tail of light in its ack of considerable ngth. | Reached quite across the heavens. | Perfectly horizontal; about S.E. to N.W. | Very brilliant. Whether the meteor became extinguished or became lost in space, could not be described. | 'Derbyshire Advertiser.' Alpheus Slight. |
| a projectile, leaving train of 5° or more, hich was dense and ntinuous with the ead, but speedily ded. Like a bomb-hell fired from London nto Ireland. | More than 60° while in sight. | E.S.E. to W.N.W., rising obliquely upwards. Rectilinear while in sight. | The train strongly visible after the meteor was hidden by the house: soared through the sky with a very majestic effect. | T. W. Webb. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, or Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1866. | h m s | | | | | |
| Jan. 11 | 9 53 30 p.m. | Royal Observatory, Greenwich. | At first equal to a 2nd mag.*; increased continually in brightness, being finally larger and brighter than Sirius. | Yellow ..... | 3 seconds..... | From a point degrees the Pleiade Piscium. Centre of opposite etis. |
| 11 | 9 54 p.m. | Bedford ..... | Brighter than Venus at its maximum. | Bright orange colour. | About 1 sec. while in sight. | First appeared $\beta$ Orionis; about 2° $\gamma$ Pegasi. |
| 11 | 9 55 p.m. | Ashford ..... | Large meteor ..... | Quite blue ... | ..... | From E., or points N. to W. |
| 11 | A few minutes before 10 p.m. | Westminster Bridge, London. | Large meteor ..... | ..... | ..... | From over the rection of beth pier; appeared be the houses Parliament. |
| 11 | 10 0 p.m. | Ticehurst (Sussex). | Much brighter than a star of the 1st magnitude. | Head and tail brilliant white. | 6 to 8 seconds. Glided as swiftly as an arrow. | From altitude E. by S.; 29° S. of zenith to alti 5° due W. |
| | | | | | | Zenith.  West. E |
| 11 | 10 0 p.m. | Bradford (Yorkshire). | Splendid meteor ... | ..... | Several secs... | Apparent from S.E. to |
| 11 | About 10 30 p.m. | Hawkhurst (Kent). | As bright as Venus at its brightest. | White ..... | 2·5 seconds ... | Disappeared way betwee Hydræ and Sextantis: halfway fro Cancri. |
| 11 | 11 33 p.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 1·5 second; very slow motion. | Disappeared Geminorum: |
| 11 | 11 38 p.m. | Ibid ..... | =1st mag.* ..... | White ..... | 0·6 second ... | From $\alpha$ Tarand $\tau$ Custodis. |

| ıranee; Train, if any, nd its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| fine train ..... | 35° ..... | Inclined ..... | This meteor, when first seen, was about the size of a second magnitude star; but throughout the whole of its course it continued to increase in brightness, until at the time of its disappearance it was larger and brighter than Sirius. | Ernest Jones. |
| a bluish train 20° in gth for 1 second. | ..... | ..... | ..... | T. G. E. Elger. |
| a Roman-candle ball; appeared without exsion; left no trace. | Complete arc of the sky. | ..... | Among some large meteors seen by the same observer, none was remembered that took such a complete circuit of the heavens. | 'The Standard,' Jan. 15th. E. M. |
| a comet; exploded last. | ..... | ..... | ..... | Communicated by T. Crumplen. |
| a sky-rocket, followed a train of light like e tail of a comet. It ually disappeared, ving the whole length its path visible by a inuous streak, which ained some seconds er the disappearance the meteor. | Nearly the whole arch of the heavens; or 160°. | Apparently in a semicircle, from E. by S. to W. by N. | Whether the meteor became exhausted or disappeared beyond the range of vision could not be determined. Clear starlight night. Altitudes and positions measured on the 15th. | R. Covington. |
| a comet ..... | Over ⅓ of the heavens. | E. to W. ..... | ..... | Communicated by R. P. Greg. |
| ppeared gradually ... | ..... | ..... | Imperfect view through a frosted window-pane. | A. S. Herschel. |
| a train for ½ a second | 5°..... | Directed from 22 Monocerotis. | Two small meteors seen in the last half-hour. Clear sky; no moon; one observer. | Id. |
| appeared suddenly; no train or sparks. | ..... | ..... | ..... | Id. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, or Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1866. | h m s | | | | | |
| Jan. 11 | 11 52 p.m. | Hawkhurst (Kent). | =3rd mag.* ..... | White ..... | 0·5 second; very swift. | From (Cor Ca ... δ Ursæ Maj ... to γ Ursæ ... joris. |
| 13 | 12 4 a.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·8 second ... | Appeared at Ursæ Maj ... course th ... quarters of way to ξ ... Majoris. |
| 15 | 9 19 p.m. | Blackheath ..... | =1st mag.*..... | Bluish white .. | Momentary ... | From a point ... or 2° abov ... Ursæ Min ... past γ Urs ... noris towa ... Draconis. |
| 15 | 9 47 p.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 1 second ..... | From about ... of Aldeb ... passed on th ... side of that ... to a point ... of c Tauri. |
| 16 | 7 55 p.m. | West Hendon (Sunderland). | =3rd mag.* ..... | Orange colour | ..... | Vanished near Lacertæ. |
| 16 | 9 53 30 p.m. | Greenwich ..... | =2nd mag.* ..... | Yellow ..... | Momentary ... | From a point ... third of the ... stance from ... dromedæ, ... suring towa ... β Andromed ... passed midw ... between ? an ... Andromedæ. |
| 16 | 10 4 p.m. | Ibid ..... | =2nd mag.* ..... | Yellow ..... | Momentary ... | Passed between Pleiades and Persei. |
| 19 | 9 24 15 p.m. | Ibid ..... | =3rd mag.* ..... | Bluish white... | 1 second ..... | From the direct ... of Pollux; ... ed midway ... tween γ and ... Geminorum, ... wards α Ori ... |
| 22 | About 7 53 p.m. | Torquay ..... | Brilliant meteor ... | Silvery blue; the fragments red. | 3 seconds ... | From a few deg ... below the P ... des to a few ... grees below ... moon. |
| 24 | 11 55 p.m. | Hawkhurst (Kent). | =3rd mag.* ..... | White ..... | 0·3 second ... | Disappeared ... (β, ψ) Ursæ ... joris. |
| 24 | 11 59 p.m. | Ibid ..... | =3rd mag.* ..... | Orange yellow | 1·3 second ... | From α to ... Ursæ Maj ... 3 Canum V ... ticorum). |

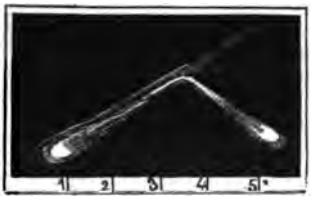
| arance; Train, if any, and its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| ain or sparks ..... | ..... | ..... | Seven meteors counted in one hour. Frosty; clear sky; no moon; one observer. | A. S. Herschel. |
| a streak for 1 second | ..... | ..... | One meteor in 15 minutes. Clear sky; no moon; one observer. | Id. |
| no train ..... | 10° ..... | Line joining $\beta$ and $\gamma$ Ursæ Minoris, parallel to track of meteor. | ..... | Thomas Wright. |
| no train ..... | 8°..... | ..... | ..... | Id. |
| ..... | ..... | ..... | ..... | T. W. Backhouse. |
| h a small train ..... | About 12°... | Nearly perpendicular ... | ..... | Ernest Jones. |
| ft a slight train ..... | 6°..... | E. to W.; horizontal ... | ..... | Id. |
| ft no train ..... | 10° ..... | Slightly inclined from horizontal. Line joining $\gamma$ and $\nu$ Geminorum, at right angles to track of meteor. | ..... | Thomas Wright. |
| ..... | 30° ..... | ..... | A report as of a distant gun was heard at an interval variously estimated at 15 to 45 seconds. | 'Torquay Directory,' Jan. 24th. |
| ft no train ..... | 4°..... | Directed from $\theta$ Ursæ Majoris. | ..... | A. S. Herschel. |
| eached a distinct maximum, with sparks at the last part of its flight. | ..... | ..... | ..... | Id. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, or Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1866. Jan. 23 | h m 12 2 a.m. | Hawkhurst (Kent). | = 2nd mag.* ..... | White ..... | 0·6 second ... | From ½ (ιη, ε) C todis to ε Cas peiæ. |
| 25 | 12 17 a.m. | Ibid ..... | = 2nd mag.* ..... | White ..... | 1·1 second ... | From θ Leonis t (ο, ξ) Virginis. |
| 31 | 10 0 p.m. | Sandhurst, Melbourne, Australia. | Large and brilliant as a rocket. | ..... | Duration nearly a minute. | Passed nearly o head, from altitude of al 45° in the to an altitude about 20° i. E. |
| Feb. 2 | 5 45 p.m. | Hawkhurst (Kent). | = 3rd mag.* ..... | Yellow ..... | 1 second ..... | From γ to β scium and wards as m beyond. |
| 2 | 5 55 p.m. | Ibid ..... | = 1st mag.* ..... | Yellow ..... | 1·2 second ... | From θ Tauri t Orionis. |
| 2 | 6 4 p.m. | Ibid ..... | = 3rd mag.* ..... | Yellow ..... | 1 second ..... | From α Aurig β Tauri. |
| 2 | 6 56 p.m. | Greenwich ..... | = 1st mag.* ..... | Bright blue ... | 1 second ..... | Passed across Eridani; ces of path near t star. |
| 2 | 9 5 p.m. | Weston-super-Mare. | = Sirius; then = 3rd mag.* | Orange, then deep red. | 2 seconds..... | From κ Draconis η Ursæ Majo |
| 3 | 9 36 p.m. | Hawkhurst (Kent). | = 3rd mag.* ..... | Yellow ..... | 0·8 second ... | Disappeared at centre of co at ξ Cephei. |
| 4 | 6 56 p.m. | Primrose Hill (London). | = Polaris ..... | White ..... | Momentary ... | α = ζ From 195° + 3 to 203 + 3 |
| 4 | 7 34 p.m. | West Hendon (Sunderland). | = 3rd mag.* ..... | Orange colour | ..... | Between the Hyades and Aurigæ. |
| 7 | 8 23 p.m. | Greenwich ..... | = 2nd mag.* ..... | Bluish white... | 1 second ..... | From a point few degrees of Cor Caro passed that s towards η U Majoris. |
| 10 | 7 16 p.m. | Primrose Hill (London). | = β Aurigæ ..... | White ..... | 0·7 second ... | From ½ (β A rigæ, α Ge norum). |
| 10 | 7 30 p.m. | Ladywell (Lewisham). | = 3rd mag.* ..... | Bluish ..... | 0·5 second ... | Appeared about below A, a disappeared b tween ζ and Draconis. |

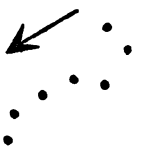
| ırance; Train, if any, ınd its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| ain or sparks ..... | ..... | ..... | ..... | A. S. Herschel. |
| ain or sparks ..... | ..... | ..... | Four meteors counted in 35 minutes. Clear sky; half moon; one observer. | Id. |
| ..... | ..... | E. to W.; inclined ..... | Although the full moon was shining brightly, the meteor was still extremely brilliant. | 'Illustrated Melbourne Post,' Feb. 23rd. |
| rain or sparks ..... | ..... | ..... | ..... | A. S. Herschel. |
| a streak for 1 second | ..... | ..... | ..... | Id. |
| rain or sparks ..... | ..... | ..... | ..... | Id. |
| ..... | 15° ..... | Inclined at an angle of 45°. | Line of flight nearly parallel to line of Orion's belt. | W. C. Nash. |
| dually relaxed its peed, and changed s appearance; like substance burning ut. | ..... | ..... | During the hour from 8 to 9 o'clock p.m., Feb. 7th, bright aurora. | W. H. Wood. |
| train or sparks ..... | ..... | ..... | Five meteors in 30 minutes. Clear sky; no moon; one observer. | A. S. Herschel. |
| ..... | 5° ..... | Inclined downwards; slightly to left. | ..... | T. Crumplen. |
| ..... | ..... | At an angle of 45°; downwards to the left. | ..... | T. W. Backhouse. |
| ft no train ..... | 8° ..... | Slightly inclined from horizontal. Line joining Cor Caroli and $\eta$ Ursæ Majoris, parallel to track of meteor. | ..... | Thomas Wright. |
| ft a bright train 3° in length. | 15° ..... | Inclined to the left, towards $\eta$ Cassiopeiæ. | ..... | T. Crumplen. |
| ft no train ..... | 5° ..... | ..... | ..... | F. P. Trapaud. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, a Altitude a Azimuth. |
|---|---|---|---|---|---|---|
| 1866. Feb. 10 | h m s 8 33 p.m. | Tooting (Surrey) | =2nd mag.* ..... | Yellow ..... | 0·5 second ... | From a point ν; passed midway bet ξ and γ conis. |
| 10 | 9 16 p.m. | Royal Observatory, Greenwich. | Twice as bright as Sirius. | Brilliant blue.. | Very rapid motion. | From a poin or 3° W. Cephei tow α Cygni. |
| 11 | 0 52 a.m. | Greenwich ..... | =2nd mag.* ..... | Bluish white... | Momentary ... | From ε Ursæ joris tow Castor. |
| 13 | 12 0 15 a.m. | London ..... | Five times as bright as α Persei. | Pale blue to white, and finally orange. | 3·5 seconds ... | From near Pe passing bet δ and λ Pe and onwar very near φ T |
| 13 | 7 11 p.m. | West Hendon, Sunderland. | =Sirius ..... | Yellow ..... | ..... | Disappeared 1° of 6 Lacertæ. |
| 13 | 8 16 p.m. | Ibid ..... | =Sirius ..... | Deep orange... | ..... | Disappeared ½° of 11 Lacertæ |
| 13 | 9 18 5 p.m. | Royal Observatory, Greenwich. | =2nd mag.* ..... | Yellow ..... | Less than 0·5 second. | From the direct of ε Cassiope passed across zenith, mid between Cap and ε Aurigæ wards θ Aur |
| 13 | 9 25 35 p.m. | Ibid ..... | =4th mag.* ..... | Bluish white... | 0·5 second ... | Passed across Ursæ Majoris a point 2° 3° beyond t star. |
| 13 | 9 45 55 p.m. | Ibid ..... | =3rd mag*. ..... | Bluish white... | 0·5 second ... | Passed across Cassiopeiæ, disappeared Cassiopeiæ. |
| 13 | 10 0 p.m. | Weston-super-Mare. | =3rd mag.* ..... | Blue ..... | 0·5 second ... | From R.A. 87°, Decl. 3° to Orionis. |
| 19 | 9 23 p.m. | Hawkhurst (Kent). | =3rd mag.* ..... | White ..... | 0·6 second ... | From H to B C melopardi. |

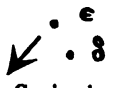
| arance; Train, if any, and its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| slight train ..... | ..... | E. to W.; slightly inclined from horizontal. | ..... | Ernest Jones. |
| no train ..... | 10° ..... | Perpendicular ..... | ..... | Arthur Harding. |
| no train ..... | 8°..... | ..... | Faint auroral light ..... | W. C. Nash. |
| meteor separated into parts, apparently the accumulation matter at the rear of nucleus. | 35° or more | Inclined downwards to left. | Began as a 5th mag.*, and gradually increased in brightness. | T. Crumplen. |
| n of bright sparks or 3° long, vanishg at the same time the head. | Very short.. | Down, a little to the left | ..... | T. W. Backhouse. |
| parkling train, about long, vanishing with e head. | About 20°... | Down, a little to the right. | ..... | Id. |
| no train ..... | 12° ..... | ..... | Very rapid motion ..... | Thomas Wright. |
| no train ..... | 7° or 8° ... | Towards N., near the zenith; directed from λ Ursæ Majoris. | ..... | W. C. Nash. |
| no train ..... | 6°..... | Inclined; directed from γ Cephei. | ..... | W. C. Nash and Ernest Jones. |
| ..... | ..... | ..... | From $4^h$ to $5^h$ a.m., on the 21st, a superb display of aurora borealis between N.E. and N.W. parts of the horizon. | W. H. Wood. |
| most stationary meteor.. | 2°..... | ..... | One meteor in 30 minutes. Clear sky; crescent moon; one observer. | A. S. Herschel. |



| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1866. | h m s | | | | | |
| Feb. 22 | 8 30 p.m. | Sandwick, Scotland. | Larger than the moon. | ..... | ..... | ..... |
| 22 | 8 45 p.m. | Kirkwall, Scotland. | Larger than the moon. | Blue ..... | Rapid ..... | ..... |
| 23 | 9 36 p.m. | West Hendon, Sunderland. | = 1st or 2nd mag.* | ..... | Very quick ... | 2° or 3° left u Andromedæ. |
| Mar. 1 | 9 16 p.m. | Eltham ..... | As bright as Venus | Yellowish white. | 0·7 second ... | Point of app ance about N. of α Ursæ joris (at altit about 50° N.N.E.). |
| 6 | 11 9 51 p.m. | Greenwich ..... | = 3rd mag.* ..... | White ..... | 0·7 second ... | Passed about below α Hyd centre of p nearly oppo that star. |
| 6 | 11 28 p.m. | Hawkhurst (Kent). | = 3rd mag.* ..... | Yellow ..... | 0·6 second ... | From λ to *i* Boö |
| 7 | 11 15 p.m. | Ibid ..... | = 3rd mag.* ..... | White ..... | 0·8 second ... | Disappeared at Persei. Cou three-quarters the way from Camelopardi. |
| 7 | 11 28 p.m. | Ibid ..... | = 3rd mag.* ..... | White ..... | 0·6 second ... | From β Leonis ½ σ Leonis, Virginis, and beyond. |
| 7 | 11 29 p.m. | Ibid ..... | = 1st mag.* ..... | White ..... | 1·1 second ... | Disappeared at Path ⅔ of th way from α Ur Majoris. |
| 7 | 11 52 p.m. | Ibid ..... | = 3rd mag.* ..... | White ..... | 2·2 seconds ... | From 12 to *g* Lyn and onwards h as far again. |
| 7 | 11 58 p.m. | Ibid ..... | = 2nd mag.* ..... | White ..... | 0·6 second ... | From Cor Caroli. of the way to Ophiuchi. |
| 8 | 8 15 43 p.m. | Blackheath ..... | = 3rd mag.* ..... | White ..... | Less than 1 sec. | Fell vertically fro a point near Persei almost β Trianguli. |

| rance; Train, if any, id its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| ..... | ..... | N.E. to S.W. ..... | A remarkable fireball. (Seen also at Ballater, and described as a remarkably large meteor.) | Symons's Monthly Meteorol. Mag. |
| ody of the meteor ually became blue t passed to S.E. A of fire followed the eor in its course. | ..... | N.E. to S.W. ..... | The light of the meteor was so vivid as to dim the gas-lights in the houses. The meteor exploded with a loud report, which sounded like distant thunder, and was heard at an interval of 2 minutes after the disappearance of the meteor. | A. Iverach, Journ. Scot. Meteorol. Soc. July 1866, vol. i. p. 374. |
| ..... | ..... | Downwards, 5° to the right. | ..... | T. W. Backhouse. |
| a fine train ..... | About 7°... | Inclined .....  | Moon shining brightly; cirro-cumulus clouds. Meteor seen this side of the clouds. | W. C. Nash. |
| no train ..... | ..... | E. to W.; inclined at an angle of 20° from horizontal. Directed from e Virginis. | ..... | Id. |
| rain or sparks ..... | ..... | ..... | ..... | A. S. Herschel. |
| rain or sparks ..... | ..... | ..... | ..... | Id. |
| rain or sparks ..... | ..... | ..... | ..... | Id. |
| rain or sparks ..... | ..... | ..... | ..... | Id. |
| rain or sparks ..... | ..... | ..... | ..... | Id. |
| rain or sparks ..... | ..... | ..... | ..... | Id. |
| ft no train ..... | 30° ..... | Perpendicular ..... | ..... | W. C. Nash. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1866. Mar. | h m s | | | | | |
| 12 | 10 39 p.m. | Hawkhurst (Kent). | =3rd mag.* | Yellow | 1 second | From λ Dra to K Cas pardi. |
| 12 | 11 0 p.m. | Ibid | =3rd mag.* | Yellow | 0·8 second | From ω to π U Majoris. |
| 12 | 11 12 p.m. | Ibid | =2nd mag.* | White | 0·4 second | From ε Dra to ½ (N. Ca lopardi, δ U Minoris). |
| 12 | 11 23 p.m. | Greenwich | =3rd mag.* | Yellow | Momentary | From a point degrees bel Cassiopeiæ: nearly verti |
| 12 | 11 25 p.m. | Hawkhurst (Kent). | =3rd mag.* | Yellow | 0·8 second | From ε, halfw δ Boötis. |
| 12 | 11 30 p.m. | Ibid | =3rd mag.* | Yellow | 0·8 second | From ½ (γ, ζ) U Majoris to λ conis. |
| 12 | 11 33 p.m. | Greenwich | =1st mag.* | Bluish | 2 seconds | From a point below δ; pa midway bet ζ and γ ginis. |
| 12 | 11 36 p.m. | Hawkhurst (Kent). | =2nd mag.* | White | 1·3 second | From δ Virgi to ½ (ζ, Boötis. |
| 12 | 11 42 p.m. | Ibid | =2nd mag.* | White | 1·2 second | Began midw between ζ Se pentis and Boötis. |
| 12 | 11 45 p.m. | Ibid | =2nd mag.* | White | 0·5 second | Disappeared at Draconis. |
| 12 | 11 58 30 p.m. | Greenwich | =2nd mag.* | Bluish | ½ second | Point of appe ance midway be tween β and Serpentis. |
| 13 | 8 26 p.m. | Ibid | =2nd mag.* | Bluish white | 0·7 second | Passed across and disappeare close to α Dra conis. |
| 14 | 10 3 p.m. | Ibid | =3rd mag.* | Blue | 1·5 second | From a point jus below δ Dra conis. |
| 14 | 10 7 p.m. | Ibid | =2nd mag.* | Blue | 1 second | From a point abou 3° W., and abov Polaris; fell to wards γ Cephei. |
| 14 | 10 9 p.m. | Ibid | =2nd mag.* | Bluish white | Rapid motion | From the direc tion of χ to point just be low α Ursæ Ma joris. |

| ...arance; Train, if any, and its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| ...in or sparks | | | | A. S. Herschel. |
| ...in or sparks | | | | Id. |
| ...in or sparks; bright-...at the middle of its ...h. | | | | Id. |
| ...o train | 5° | Nearly perpendicular | | Ernest Jones. |
| | |  Cassiopeia. | | |
| ...in or sparks | | | | A. S. Herschel. |
| ...in or sparks | | | | Id. |
| ...a fine train | 10° | Directed from $\beta$ Leonis | | Ernest Jones. |
| ...ain or sparks | | | Probably same as the preceding meteor. | A. S. Herschel. |
| ...ain or sparks | 6° | Directed from $\psi$ Boötis. | | Id. |
| ...htest at middle of its ...th. | | Halfway from $\eta$ Ursæ Majoris. | Seven meteors in one hour. Clear sky; no moon; one observer. | Id. |
| ...a slight train | 5° | S. to N., nearly horizontal. | | Ernest Jones. |
| ...a train and sparks at ...appearance. | 7° | | | W. C. Nash. |
| ...o train | 15° | Perpendicular | | Arthur Harding. |
| ...o train | 12° | Nearly vertical | | Id. |
| ...o train | 15° | Inclined | | Id. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, et Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1866. | h m | | | | | |
| Mar. 15 | 11 50 p.m. | Enys, Penrhyn (Cornwall). | Size of the moon... | Bluish ..... | Slow speed ... | In the N. .... |
| 16 | 8 16 p.m | Greenwich ..... | =2nd mag.* ..... | Bluish white... | ½ second ..... | From a point n e Gem.iorn fell towards Tauri. |
| 16 | 10 12 p.m. | Blackheath ..... | =Rigel ..... | Yellow ..... | 3 seconds..... | Fell from a po a little ab χ Persei, passed a li N. of φ And medæ. |
| 17 | 10 47 p.m. | Greenwich ..... | =Venus ..... | Yellow ..... | 1 second ..... | Passed across Cassiopeiæ (ab 5° beyond). |
| 17 | 10 47 p.m. | Lewisham ..... | Greater than 1st mag.* | Brilliant blue.. | 3 seconds ... | Passed between and γ Cas peiæ, and d appeared ne θ Cassiopeiæ. |
| 17 | 10 52 p.m. | Ibid ..... | =2nd mag.* ..... | Bluish white... | ½ second ..... | Passed from ε Ly towards β Ly |
| 17 | 11 0 p.m. | Greenwich ..... | =3rd mag.* ..... | Bluish white... | ½ second ..... | Passed across Geminorum ( beyond), f the direction θ Geminorum. |
| Apr. 10 | 9 29 p.m. | Royal Observatory, Greenwich. | =2nd mag.* ..... | Blue ..... | 1 second ..... | Disappeared b tween η and Draconis. |
| 11 | 8 45 p.m. | Blackheath ..... | =3rd mag.* ..... | Bluish white... | 1 second ..... | Passed midway b tween δ and Persei: centre track betwe those stars. |
| 13 | 9 57 p.m. | Royal Observatory, Greenwich. | =3rd mag.* ..... | Bluish white... | ½ second ..... | From the direct of α; disappear near θ Ursæ Mi joris. |
| 14 | 9 21 p.m. | Ibid ..... | =4th mag.* ..... | Bluish white... | Rapid motion | Fell vertically fro a point 2° E and above P laris. |

| ance; Train, if any, d its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| a long train. The r portion of the only seen (see h: * 1, panes of 12½ inches by 9½ es; * 2, termina- seen through trees distant fir planta- ; distance one mile). | ..... | ..... | Light enough to pick up a pin, or as light as on a rainy day. | E. Rapson, communicated by J. S. Enys and H. C. Sorby. |
| no train ..... | 7° | ..... | ..... | W. C. Nash. |
| train for 1 second ... | 15° ..... | Nearly perpendicular ... | The path of this meteor was slightly curved, thus— | Thomas Wright. |
| train ..... | 15° ..... | Directed from α Ursæ Majoris. | A very large and brilliant meteor. | W. C. Nash. |
| train for ½ second ... | 30° ..... | From α Ursæ Majoris... | Same as the preceding meteor. | Thomas Wright. |
| train ..... | 8° ..... | Inclined ..... | ..... | Id. |
| train ..... | 10° ..... | ..... | ..... | W. C. Nash. |
| no train ..... | 10° ..... | Nearly vertical. From direction of β Ursæ Minoris. | ..... | Arthur Harding. |
| no train ..... | About 6°... | Inclined ..... | ..... | Thomas Wright. |
| no train ..... | 5° ..... | Inclined ..... | ..... | Id. |
| no train ..... | 20° ..... | Perpendicular ..... | ..... | Arthur Harding. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, & Altitude & Azimuth. |
|---|---|---|---|---|---|---|
| 1866. | h m | | | | | |
| Apr. 14 | 9 36 p.m. | Royal Observatory, Greenwich. | =1st mag.* ..... | Bluish white... | ..... | From $\gamma$ Cr passed acr and $\eta$ H to a poi little abov south of $\alpha$ dræ. |
| 16 | 10 3 p.m. | Ibid ..... | =2nd mag.* ..... | Bluish ..... | 1 second ..... | Appeared mi between $\delta$ $\eta$ Hydræ, passed towa Monocerot |
| 16 | 10 16 p.m. | Blackheath ..... | =3rd mag.* ..... | Bluish white... | 1 second ..... | From a point midway bet $\eta$ and $\gamma$ Vir |
| 17 | 8 42 p.m. | Royal Observatory, Greenwich. | =3rd mag.* ..... | Blue ..... | 1 second ..... | From near $\lambda$ Canum Ve corum towa Boötis. |
| 17 | 8 47 p.m. | York..... | About the size of Jupiter. | Fine orange colour. | About 1 sec... | Commenced altitude of 40′; azi 18° 14′ W. N.; disapp at altitude azimuth 23° from N. |
| 17 | 9 13 p.m. | Royal Observatory, Greenwich. | =2nd mag.* ..... | Blue ..... | 2 seconds ... | From a point 4° from $d$ Ca Venaticorum passed a that star wards $\epsilon$ Majoris. |
| 17 | 10 14 p.m. | West Hendon (Sunderland). | =2nd mag.* ..... | Yellow ..... | ..... | Disappeared $2^d$ $\nu$ Cygni wards $\gamma$. |
| 17 | 10 18 p.m. | Ibid ..... | =2nd mag.* ..... | Yellow ..... | ..... | Disappeared near $\phi$ An medæ. |
| 18 | 10 41 p.m. | Greenwich ..... | =2nd mag.* ..... | Bluish white... | 1 second ..... | Passed across and $\beta$ Cancri |
| 19 | Evening ... | Observatory, Paris. | Large ..... | ..... | ..... | ..... |
| 19 | 10 40 p.m. | Glasgow ..... | =3rd mag.* ..... | Yellow ..... | 1 second ..... | From $\delta$ Corona $\sigma$ Herculis. |
| 21 | 10 21 p.m. (approx.) | Blackheath ..... | =3rd mag.* ..... | Bluish white... | ½ second ..... | From the direct of $\zeta$; past wards $\epsilon$ Bo |
| 21 | 10 23 p.m. (approx.) | Ibid ..... | =2nd mag.* ..... | White ..... | 1 second ... | Moved on a p parallel to a joining $\alpha$ a Coronæ. |

| ırance ; Train, if any, ıad its Duration. | Length of Path. | Direction ; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| ıo train .. | 25° | Slightly curved | | Arthur Harding. |
| ıo train | 10° | | | Ernest Jones. |
| ıo train | 5° | Inclined | | Thomas Wright. |
| ıo train | 15° | Inclined | | Arthur Harding. |
| ı into many fragments | | | No report or noise heard | T. H. Waller. |
| ı train | 12° | | | Arthur Harding. |
| | | To the right, a little downwards. | Moved slowly | T. W. Backhouse. |
| | | Perpendicularly downwards. | | Id. |
| ı train | 9° | Inclined | | W. C. Nash. |
| ıl twice | | | A considerable fireball... | Les Mondes, 2nd Ser., vol. ii. p. 7. |
| train or sparks | | | In one hour, 3 meteors : sky chiefly clear ; no moon ; one observer. | A. S. Herschel. |
| ı no train | 5° | | | Thomas Wright. |
| ı no train | 3° | Inclined | | Id. |

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| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1866. | h m | | | | | |
| Apr. 23 | 10 55 p.m. | London ..... | = α Geminorum... | White ..... | 2 seconds ... | From near above α Ge rum to 1½ low η and rigæ. |
| May 4 | 10 52 p.m. | Hawkhurst (Kent). | =3rd mag.* ..... | Yellow ..... | 0·9 second ... | From ½ (γ D nis, δ Ursæ joris) to γ Majoris. |
| 4 | 10 54 p.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·6 second ... | From δ Canu naticorum Ursæ Majo |
| 4 | 11 20 p.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·7 second ... | Disappeared Camelopard course ha from κ conis. |
| 4 | 11 38 p.m. | Ibid ..... | =1st mag.* ..... | Yellow, then reddish. | 1·2 second ... | From ν to δ C Berenices; mencing ha far before ν mæ. |
| 4 | 11 45 p.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·4 second ... | From η Draco ½ (γ, ν) Minoris. |
| 7 | 1 40 p.m. | Ladywell, Lewisham. | =3rd mag.* ..... | Blue ..... | ½ second ..... | Fell vertically a point mi between α Libræ. |
| 7 | 9 53 p.m. | Blackheath ..... | =3rd mag.* ..... | White ..... | 1 second ..... | From a point 2° E. of β L fell past γ Li and disappe near β Scorp |
| 11 | 10 50 p.m. | Hawkhurst (Kent). | =3rd mag.* ..... | Yellow ..... | 0·8 second ... | Disappeared Draconis; co halfway fro Bootis. |
| 11 | 11 14 p.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·5 second ... | Disappeared Tarandi. |
| 11 | 11 18 p.m. | Ibid ..... | =2nd mag.* ..... | Yellow ..... | 1·5 second ... | From M Ca pardi to Camelopard Custodis). |
| 11 | 11 25 p.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·6 second ... | Appeared at phei; cours of the way Cassiopeiæ. |
| 11 | 11 32 p.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 1 second ..... | From p to q Ca lopardi. |
| 11 | 11 45 p.m. | Ibid ..... | =1st mag.* ..... | White ..... | 1 second ..... | From δ Cephe ½ (ρ Cassio Honorum. |
| 11 | 11 53 p.m. | Ibid .... ..... | =2nd mag.* ..... | White ..... | 0·7 second ... | From H to ζ H conis. |

| ...earance; Train, if any, and its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| ...ular; left a slight ...in. | About 30°. | To right, inclined downwards. | ..... | T. Crumplen. |
| ...train or sparks ..... | ..... | ..... | ..... | A. S. Herschel. |
| ...train or sparks ..... | ..... | ..... | ..... | Id. |
| ...train or sparks ..... | ..... | ..... | ..... | Id. |
| ...appeared gradually ... | ..... | ..... | ..... | Id. |
| ...train or sparks ..... | ..... | ..... | Eight meteors in 1 hour: clear sky; moon in third quarter; one observer. | Id. |
| ..... | 3° ..... | Perpendicular ..... | ..... | F. Trapaud. |
| ...ht no train ..... | 10° ..... | Fell perpendicular ..... | Descended with a wavering motion. | Thomas Wright. |
| ...train or sparks ..... | ..... | ..... | ..... | A. S. Herschel. |
| ...train or sparks ..... | 10° ..... | Directed from $\chi$ Draconis. | ..... | Id. |
| ...train or sparks ..... | ..... | ..... | ..... | Id. |
| ...train or sparks ..... | ..... | ..... | Very swift ..... | Id. |
| ...ew gradually brighter and then less; no train. | 1° ..... | ..... | Nearly stationary ..... | Id. |
| ...appeared suddenly; no train or sparks. | ..... | ..... | ..... | Id. |
| ...o train or sparks ..... | ..... | ..... | Twelve meteors counted in one hour. Sky nine parts clear; no moon; one observer. | Id. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, or Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1866. May 16 | h m s 9 57 p.m. | Blackheath (Kent). | =2nd mag.* ..... | Bluish white.. | 3 seconds ... | From a poi little below W. of π Le passed mid between ε, η Hydræ tow Procyon. |
| 16 | 11 0 p.m. (approx.) | Greenwich ..... | As bright as Venus.. | Bluish white... | 1 second ..... | In S., above S pius. |
| 17 | 10 38 1 p.m. | Ibid ..... | As bright as Venus | Blue ..... | 2 seconds..... | First seen 7° below β Le moved westw passing clos Regulus. |
| 17 | 10 41 36 p.m. | Ibid ..... | =3rd mag.* ..... | Bluish white... | 0·4 second ... | Disappeared to β Virginis |
| 17 | 11 8 36 p.m. | Ibid ..... | =3rd mag.* ..... | White ..... | ½ second ..... | Disappeared ε Virginis. |
| 18 | 10 46 44 p.m. | Royal Observatory, Greenwich. | =3rd mag.* ..... | Bluish white... | 0·4 second ... | Fell from the rection of ξ, φ Boötis, tow Saturn. |
| 18 | 10 51 34 p.m. | Ibid ..... | =3rd mag.* ..... | Bluish white... | 0·3 second ... | Moved past Pol and ω Cep Line join those stars par lel to track meteor. |
| 18 | 10 53 30 p.m. | Ibid ..... | =3rd mag.* ..... | Blue ..... | 1 second ..... | From the dir tion of ε Boö across π and Boötis. |
| 18 | 11 5 45 p.m. | Ibid ..... | =2nd mag.* ..... | Bluish white... | 1 second ..... | From a point or 2° S. δ Crateris a point a the same d tance from Hydræ. |
| 18 | 11 11 9 p.m. | Ibid ..... | Brighter than a 1st mag.*. Nearly equal to Venus. | Yellowish white. | 1·5 second ... | Passed from be β Ursæ Mino to a point ne q Camelopard |
| 18 | 11 11 34 p.m. | Ibid ..... | =1st mag.*..... | Bluish white... | 1 second ..... | From ε Lyræ a point nea Cygni. |
| 18 | 11 29 49 p.m. | Ibid ..... | =1st mag.* ..... | Bluish white... | 1½ second ... | From ι Cephei to point 2° E. of Cassiopeiæ. |
| 18 | 11 40 52 p.m. | Ibid ..... | =1st mag.* ..... | Bluish white... | ½ second ..... | From γ Draco towards θ C phei. |
| 18 | 11 41 59 p.m. | Ibid ..... | =1st mag.* . .... | Bluish white... | 1 second ..... | From β to ζ Op uchi. |

| arance; Train, if any, and its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| o train | 30° | Inclined | | Thomas Wright and G. W. Farncomb. |
| | | | | W. C. Nash. |
| ain noticed | 25° or more | Inclined slightly from horizontal, | End of path not seen on account of obstacles. | Id. |
| o train | 5° | Directed from Arcturus | | Id. |
| o train | 5° or 6° | Directed from ε Virginis | | Id. |
| o train | 12° | Perpendicular | | W. C. Nash; Thomas Wright. |
| o train | 5° | Inclined | | Thomas Wright. |
| o train | 15° | Inclined | | Arthur Harding. |
| no train | 10° | Perpendicular | | Ernest Jones; Thomas Wright. |
| train; lasted one econd after the me-eor's disappearance. | 10° | | | W. C. Nash; Ernest Jones. |
| ft a fine train | 18° | Inclined | | Id. |
| ft a fine train | 14° | Nearly perpendicular | | W. C. Nash; Ernest Jones; Thomas Wright. |
| | 7° or 8° | | | W. C. Nash. |
| ft a fine train | 22° | Inclined | | W. C. Nash; Thomas Wright. |

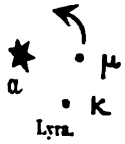
| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, or Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1866. May 18 | h m s 11 44 19 p.m. | Royal Observatory, Greenwich. | =1st mag.* ..... | Yellow ..... | 1 second ..... | From α Coro Borealis; pas midway tween ξ and Boötis. |
| 18 | 11 45 14 p.m. | Ibid ..... | =2nd mag.* ..... | Bluish white... | 0·5 second ... | Moved past γ β. Ophiuchi. Line joining those stars pa lel to track meteor. |
| 18 | 11 47 49 p.m. | Ibid ..... | =1st mag.*..... | Bluish white... | 1 second ..... | Fell past η and Boötis. |
| 18 | 12 0 p.m. | Ibid ..... | =2nd mag.* ..... | Bluish white... | 0·5 second ... | Moved past ε ε Ophiuchi. |
| 19 | 0 26 25 p.m. | Ibid ..... | =2nd mag.* ..... | Bluish white... | 1 second ..... | From δ Coro Borealis; π Herculis t wards ε H culis. |
| 19 | 0 30 a.m. | Ibid ..... | =2nd mag.* ..... | Bluish ..... | ½ second ..... | From the di tion of β U Majoris; pas between μ λ Ursæ Ma ris to a po near d Le Minoris. |
| 19 | 1 0 a.m. | Ibid ..... | =1st mag.* ..... | Bluish white... | 1 second ..... | From a point or 3° left of Ursæ Majori fell vertica towards the h rizon. |
| 19 | 2 50 a.m. | London ..... | =3rd mag.* ..... | White ..... | 1·2 second ... | From ½ (γ, A) B ötis to γ Ur Majoris. |
| 20 | 11 23 p.m. | Ibid ..... | =3rd mag.* ..... | White ..... | 0·5 second ... | From ν to τ Cyg |
| June 13 | 12 30 to 12 45 a.m. | Hawkhurst (Kent). | ..... | ..... | ..... | ..... |
| 20 | 10 40 a.m. | East Hill, Hastings. | Very bright meteor | ..... | ..... | ..... |
| 20 | 10 45 a.m. | Folkstone..... | Large meteor ..... | ..... | ..... | Traversed the s at an elevati of about 45°. |

| arance; Train, if any, and its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| a fine train ..... | 20° ..... | Inclined ..... | ..... | W. C. Nash; Thomas Wright. |
| no train ..... | 7° ..... | ..... | ..... | Id. |
| no train ..... | 5° ..... | Perpendicular ..... | ..... | Thomas Wright. |
| no train ..... | 6° ..... | Inclined ..... | ..... | Id. |
| no train ..... | 10° ..... | Inclined ..... | ..... | Id. |
| a fine train ..... | 20° ..... | Inclined ..... | ..... | Ernest Jones. |
| ..... | 20° ..... | Perpendicular ..... | ..... | W. C. Nash. |
| train or sparks ..... | ..... | ..... | ..... | A. S. Herschel. |
| train or sparks ..... | ..... | ..... | One meteor in thirty minutes; clear sky; half moon; one observer. | Id. |
| ..... ..... | ..... | ..... | A strict watch kept for meteors; none seen; clear sky; no moon. | Id. |
| ng-shaped; left a long streak in the sky visible for about 5 minutes. | ..... | N.E. to S.W. ..... | Followed by two reports like thunder immediately afterwards. | J. Shudy, Coast-guard Report, Hastings. |
| ft a perfect train of smoke, which remained distinctly visible for some time, and gradually dispersed over the sea. | ..... | From N. to S. ..... | Seen shining brightly. Atmosphere quite clear. Four or five minutes afterwards a double report was heard much louder than two pieces of ordnance fired on the heights of Dover. | The 'Times,' June 21st. |

| Date. | Time. | Place of Observation. | Apparent Size. | Colour. | Direction. | Position, a Altitude an Azimuth. |
|---|---|---|---|---|---|---|
| 1887. June 20 | h m 10 45 a.m. | Dover Castle | Brilliant meteor | | | Disappeared hind a ri ground; a thin line smoke w marked its for about minute. |
| 20 | 10 45 a.m. | Boulogne | | | | |
| 20 | 10 45 a.m. | Ticehurst, Sussex | Half as large as the moon, and very much more brilliant than the moon when seen in the day. | | Flight not rapid; motion smooth and regular; gliding in its course as a heavy body might be supposed to do. | Appeared in E. N. at an altit of 15°, and appeared in S at an altitude 5°. |
| 20 | 10 45 a.m. | Penshurst, Kent. | The length of the meteor was about once or twice the apparent diameter of the moon. | White and red | Motion rapid; more than 2 seconds. | About 35° ab the horizon. |
| 20 | 10 45 a.m. | Steyning, Sussex | Large meteor, very bright. | Almost white, tail red. | 10 seconds; steady motion. | Came from N.E., and pas into the S.W. |
| 20 | 11 0 p.m. (Paris time) | Boulogne | | | | Position of the tr from altitude 5 magnetic azim (E. from N.) 9 to altitude 4 magnetic azim (E. from N.) 19 |

| ance; Train, if any, d its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| ..... | ..... | From a point N.W. to S. | In about 30 seconds, a loud report was heard from the direction in which it disappeared. | 'Evening Mail,' 'Times,' &c. |
| ..... | ..... | ..... | A loud report shook the houses; the first report was sharp and decisive, but there ensued a dull noise, which lasted several seconds, and which appeared to recede equally on all sides. From a window was seen a long strip of vapour, not very high up and of a uniform pattern, very delicately traced, which was noticed by others a considerable time previous to the first shock. | Communicated by Sir J. Herschel; Hesketh Smith. |
| wed by a short train, ich appeared to draw a point behind the d, and rapidly died t. | ..... | ..... | The day was fine but partially clouded, and the sun shone out very clearly and warm at intervals. (See Appendix II., 6.) | Communicated by R. Covington. |
| advancing end was illiant red, with a hite or shining en- lope or head. | 80° ..... | N.W. to S.E., nearly parallel to the horizon, but with a slight decline to S.E. | Moved across the clear sky, and disappeared behind a mass of clouds; no report heard. | J. Nasmyth. |
| wed by a very long ery tail. Presented an c of a very large circle. | ..... | N.E. to S.W. ..... | Sun very bright, and a clear sky. A railway train near prevented anything else being heard. | Edmund Young. |
| ng narrow smoke-like rain remained in the ky, where a final puff arked the place of xplosion with perfect listinctness. | ..... | ..... | An explosion, followed by a low and continued rumbling, was heard. The meteor itself was not seen. (See Appendix II., 6.) | F. Galton. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| [illegible] | h m | | | | | |
| [illegible] | 1 p.m. | Various. Westminster. Kent. | | | | |
| 25 | 2 22 a.m. (mean time) | Delft, Holland | Large meteor | Golden | | |
| 24 | 1 13 p.m. | Derby | One quarter of the apparent diameter of the moon. | Pure white; intense light but colourless. | 2 seconds; very rapid. | First appeared at $\beta$ Lyræ, passed across Herculis and Coronæ; disappearing behind buildings in W.S.W. |
| July 5 | About noon | Hawkhurst, Kent. | Large meteor | Silvery white. | | Moved along the above the edge of a dark cl |
| 11 | 11 0 to 11 20 p.m. | Ibid | | | | |
| 15 | 0 50 a.m. | Primrose Hill, London. | = 2nd or 3rd mag.* | Light orange colour. | | Three rather bri shooting - st near $\gamma$ Pegasi. |
| 15 | 11 29 p.m. | Ibid | = 2nd mag.* | White | 0·8 second | Commenced at Lyræ. |
| 15 | 11 37 p.m. | Ibid | = 3rd mag.* | Yellow | 0·5 second | From $\alpha$ Aqu to $k$ Scuti biesii. |
| 16 | 10 35 p.m. | Birmingham | = 1st mag.* | Yellow | 1 second | From $\epsilon$ Aquilæ a point in R. 263°, N. De 9°. |
| 16 | 10 42 p.m. | Ibid | = 2nd mag.* | White | 0·5 second | From $\beta$ Cygni to point in R. 295°, N. De 32°. |
| 16 | 10 46 p.m. | Ibid | = 2nd mag.* | Blue | 0·5 second | From $\alpha$ Cygni to Sagittæ. |
| 16 | 10 45 p.m. | Ibid | = 3rd mag.* | Yellow | 0·7 second | From 42 (Fl.) Dr conis to $\psi$ Dr conis. |
| 16 | 11 0 p.m. | Ibid | = 2nd mag.* | White | 1·2 second | From 2° S. of Camelopardi 1° N. of $\eta$ Ur Majoris. |

| arance; Train, if any, and its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| ..... | ..... | ..... | A shock like that of a heavy body falling over head shook the houses and windows, and startled labourers in the fields. There were two reports, the first from S.W., the second from N.E. or E.; the second sounded like an echo of the first. | ..... |
| eal in form. Four nes as long as broad. Head was an ellipsoid, ith its major axis perendicular to the appaent course of the meor, followed by a very ender tail 7° or 8° in ngth. | ..... | ..... | For noonday, it was marvellously distinct. | The 'Times,' R. P. |
| | Nearly 60° | Apparent course a perfect right line. | No sound was heard during or after its disappearance. | The 'Times,' J. Vertu. |
| ..... | ..... | ..... | Seen in sunshine..... | Communicated by A. S. Herschel. |
| ..... | ..... | ..... | No meteors visible in 30 minutes: clear sky; no moon; one observer. | A. S. Herschel. |
| slight trains. ..... | About 5° ... | Inclined downwards to left. | Radiant, near γ Pegasi.. | T. Crumplen. |
| ..... | 2°..... | Directed from κ Lyræ... | Short path, curved towards α Lyræ. | Id. |
|   | | | | |
| ..... | ..... | Radiant in Cassiopeia or Perseus. | ..... | Id. |
| ft a train ..... | ..... | ..... | ..... | W. H. Wood. |
| ft a train ..... | ..... | ..... | ..... | Id. |
| train or sparks ..... | ..... | ..... | ..... | Id. |
| train or sparks ..... | ..... | ..... | ..... | Id. |
| eft a streak on its whole course for 1¼ second. | ..... | Radiant in Cassiopeia or Perseus. | ..... | Id. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position. Altitude Azimuth. |
|---|---|---|---|---|---|---|
| 1866. | h m | | | | | |
| July 17 | 8 52 p.m. | Eidfjord, Norway, N. lat. 60° 20′, W. long. 7° 8′. | Far brighter than the full moon. | Bright green... | ..... | Disappeared W.N.W., pe 20° in altitu |
| 17 | 11 0 p.m. | Hawkhurst (Kent). | =2nd mag.* ..... | White ..... | 0·9 second ... | From $\theta$ to $\alpha$ C |
| 17 | 11 20 p.m. | Ibid ..... | =1st mag.* ..... | White, then deep red. | 7 seconds; well counted. | From $\beta$ Oph to $\frac{1}{2}$ ($\pi$, $\sigma$ gittarii. |
| 17 | 11 29 p.m. | Ibid ..... | =2nd mag.* ..... | White, then red. | 1·1 second ... | Disappeared ($\nu$,$\sigma$); cours way from $\eta$ C |
| 17 | 11 37 p.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·6 second ... | Commenced Cassiopeiæ. |
| 17 | 11 38 p.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·4 second; very swift. | From $\mu$ Draco $V_2$ Herculis |
| 17 | 11 58 p.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·3 second; very swift. | From $\pi$ to $\epsilon$ L |
| 18 | 11 28 p.m. | Ibid ..... | =2nd mag.* ..... | White ..... | 0·6 second ... | From $\theta$ to $\alpha$ dromedæ. |
| Aug. 4 | 9 54 p.m. | Primrose Hill (London). | =3rd mag.* ..... | ..... | Rapid ..... | Centre of pat tween $\rho$, $\sigma$ Poniatovii. |
| 4 | 10 5 p.m. | Ibid ..... | =$\beta$ Aquilæ ..... | Yellow ..... | 0·5 second ... | Commenced Aquilæ. |
| 5 | 9 56 p.m. | Ibid ..... | =2nd mag.* ..... | White ..... | Rapid ..... | From near Aquilæ, to n Aquarii. |
| 5 | 9 57 p.m. | Ibid ..... | =1st mag.* ..... | White ..... | ..... | Commenced $\beta$, $\gamma$ Lyræ. |
| 5 | 10 42 p.m. | Ibid ..... | =$\alpha$ Aquilæ ..... | White ..... | 0·5 second ... | From near $\gamma$ C to $\alpha$ Aquilæ. |
| 7 | 9 20 p.m. | Ibid ..... | =1st mag.* ..... | Pale blue..... | Moved slowly. | From $\gamma$ Delphi |
| 7 | 9 40 p.m. | Ibid ..... | =$\alpha$ Lyræ..... | Pale blue..... | Rapid motion | Appeared at $\alpha$ I |
| 8 | About 8 15 p.m. | Hawkhurst (Kent). | Nearly half as large as the moon and much brighter. | White or yellowish. | 3 seconds ... | From alt. 25°, muth W. fro 110°, to alt. azimuth W. S. 65°. Ap mate pos measured some afterwards, fr bearings. |
| 8 | 8 15 p.m. | Bristol ..... | Large meteor ..... | ..... | ..... | ..... |

| rance; Train, if any, nd its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| 5° or 10° long; also ke. | At least 50° | ..... | (See Appendix II., 7)... | T. W. Backhouse. |
| ia or sparks ..... | ..... | ..... | ..... | A. S. Herschel. |
| ..... | ..... | ..... | ..... | Id. |
| test at middle of its h; grew gradually . No train or sparks. | ..... | ..... | ..... | Id. |
| a streak for 2 seconds | 2°..... | Directed from Algol ... | Fifteen meteors in one hour: clear sky; no moon; one observer. | Id. |
| a streak on its whole rse for 2½ seconds. | 15° or 20°... | ..... | Meteors with streaks, shooting from the 10th of Aug. radiant, in Perseus and Cassiopeia since the 15th. | Id. |
| htest at the middle of course. Left no reak. | ..... | ..... | ..... | Id. |
| a streak on its whole rse for 2 seconds. | ..... | Directed from Perseus.. | Seven meteors in thirty minutes: clear sky; no moon; one observer. | Id. |
| a streak on its whole rse. | 10° ..... | Downwards, parallel to the Milky Way. | ..... | T. Crumplen. |
| a broad streak on its hole course. | 5° ..... | Slightly upwards, towards ζ Aquilæ. | A perceptible planetary disk. | Id. |
| a long bright streak... | ..... | Downwards to left ..... | Cloudy on the night of the 6th. | Id. |
| y bright, planetary appearance. | 10° or 12°... | Downwards, almost at right angles to Milky Way. | Occurred while recording the previous meteor. | Id. |
| ght planetary disk. Left a train 5° in ength. | 20° ..... | Downwards, crossing the Milky Way. | Two small meteors at $10^h$ $10^m$; no others seen for 10 minutes. | Id. |
| e-shaped: grew gradually less. | 8°..... | Directed towards μ Cygni. | Followed by a smaller meteor from γ Delphini within 15 secs.; path more horizontal, to left. | Id. |
| ..... | ..... | Directed towards β Herculis. | Path intercepted by buildings. | Id. |
| ich longer than broad, tapering behind to a tail. Disappeared without bursting. Left a streak for some seconds. | 50° ..... | Inclined ..... | Seen in full twilight. Passed in its transit behind a tree, through the branches of which it shone as brightly as a lantern. | Communicated by A. S. Herschel. |
| ..... | ..... | ..... | ..... | Communicated by W. H. Wood. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, a Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1866. Aug. 8 | h m 11 20 p.m. | Birmingham ... | =3rd mag.* ..... | Blue ..... | 1 second ..... | From θ to χ Aqu |
| 8 | 11 27 p.m. | Ibid ..... | As bright as Sirius.. | Brilliant blue.. | 0·75 second ... | From 50° + to 48 + |
| 8 | 11 31 p.m. | Ibid ..... | =2nd mag.* ..... | Blue ..... | 0·5 second ... | From ½ (α Ce Polaris) to laris. |
| 8 | 11 33 p.m. | Ibid ..... | =2nd mag.* ..... | Blue ..... | 0·5 second ... | From λ Androm to α Cephei. |
| 8 | 11 35 p.m. | Ibid ..... | =2nd mag.* ..... | Blue ..... | 0 4 second ... | From α Cephi Polaris. |
| 8 | 11 39 p.m. | Ibid ..... | =2nd mag.* ..... | Blue ..... | 0·5 second ... | From α Trian to α Arietis. |
| 8 | 11 43 p.m. | Ibid ..... | =3rd mag.* ..... | Blue ..... ... | 0·5 second ... | From 5° – to 348 – |
| 8 | 11 49 p.m. | Ibid ..... | =1st mag.* ..... | White ..... | 0·5 second ... | From γ Urs noris to Cor C |
| 8 | 11 51 p.m. | Ibid ..... | =2nd mag.* ..... | Blue ..... | 0·75 second ... | From α to Aquarii. |
| 9 | 0 7 a.m. | Ibid ..... | As bright as Sirius.. | Orange colour | 0·75 second ... | From ν Persi R. A. 60°, Decl. 35°. |
| 9 | 0 7 a.m. | Ibid ..... | =3rd mag.* ..... | Blue ..... | 0·3 second ... | From ν Persi Musca. |
| 9 | 0 12 a.m. | Ibid ..... | =1st mag.* ..... | White ..... | 0·25 second ... | From θ Urs joris to R 115°, N. De 50°. |
| 9 | 9 47 p.m. | Ibid ..... | Brighter than 1st mag.* | Brilliant blue.. | 1 second ..... | From α Lyrs to Ophiuchi. |
| 9 | 10 22 p.m. | Ibid ..... | =1st mag.* ..... | Orange colour | 0·5 second ... | From ρ to α Boö |
| 9 | 10 26 p.m. | Ibid ..... | =2nd mag.* ..... | Yellow ..... | 0·6 second ... | From α Boötis R. A. 220°, Decl. 10°. |
| 9 | 10 40 p.m. | Ibid ..... | =2nd mag.* ..... | Orange colour | 0·5 second ... | From d to α U Majoris. |
| 9 | 10 56 p.m. | Ibid ..... | =2nd mag.* ..... | Yellow ..... | 0·5 second ... | From ε Cygni to Delphini. |
| 9 | 10 57 p.m. | Primrose Hill (London). | =1st mag.* ..... | Pale blue ..... | 0·5 second ... | Commenced from χ Persi. |
| 9 | 11 0 p.m. | Birmingham ... | =3rd mag.* ..... | Blue ..... | 1 second ..... | From α Trian to R. A. 20 Decl. 15°. |
| 9 | 11 3 p.m. | Ibid ..... | =3rd mag.* ..... | Blue ..... | 0·5 second ... | From ι Draconi to α Coronæ. |
| 9 | 11 6 p.m. | Ibid ..... | As bright as Sirius.. | Brilliant white | 0·3 second; very rapid. | From κ Ophiuc to R. A. 219°, Decl. 6°. |

| rance; Train, if any, nd its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| ..... | ..... | ..... | Distant lightning in N. at $10^h\ 25^m$ p.m.; cloudy and showery until $11^h\ 10^m$ p.m., then clear. | W. H. Wood. |
| ..... | ..... | Directed from $\delta$ Persei.. | ..... | Id. |
| train ..... | ..... | Directed from $\beta$ Cephei | ..... | Id. |
| ..... | ..... | Directed from $\delta$ Andromedæ. | ..... | Id. |
| ..... | ..... | Directed from $\beta$ Cephei | ..... | Id. |
| ..... | ..... | Directed from $\beta$ Cephei | ..... | Id. |
| ..... | ..... | Directed from $\delta$ Persei.. | ..... | Id. |
| a train ..... | ..... | Directed from $\delta$ Camelopardi. | ..... | Id. |
| ..... | ..... | Directed from $\delta$ Persei.. | ..... | Id. |
| a red train ..... | ..... | Directed from $\nu$ Persei.. | This meteor and the following were simultaneous. | Id. |
| ..... | ..... | Directed from $\nu$ Persei.. | ..... | Id. |
| ..... | ..... | ..... | Twelve meteors observed, and recorded, per hour, by one observer. | Id. |
| or sparkled ..... | ..... | Directed from $\kappa$ Persei.. | Sky clear at 10 p.m. ... | Id. |
| ..... | ..... | Directed from $\beta$ Cephei | ..... | Id. |
| ..... | ..... | Directed from $\epsilon$ Persei.. | ..... | Id. |
| a train ..... | ..... | Directed from $\varkappa$ Camelopardi. | ..... | Id. |
| a train ..... | ..... | Directed from P Camelopardi. | Clouds gathering..... | Id. |
| a broad bluish streak r $\frac{1}{2}$ of a second, fading adually. | 10° ..... | Directed from $\chi$ Persei towards a point $3\frac{1}{2}°$ below Polaris. | Night of the 8th rainy. Two other small meteors from Perseus. | T. Crumplen. |
| ..... | ..... | Directed from $\kappa$ Persei.. | ..... | W. H. Wood. |
| ..... | ..... | Directed from $\delta$ Persei.. | ..... | Id. |
| eor increased in size nd flickered. | ..... | Directed from P Persei.. | Angular path thus ..... | Id. |

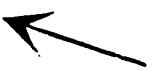
| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, a Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1866. | h m | | | | | |
| Aug. 9 | 11 11 p.m. | Primrose Hill (London). | =3rd mag.* ..... | ..... | ..... | First appeared ε γ Draconis. |
| 9 | 11 12 p.m. | Ibid ..... | =2nd mag.* ..... | White ..... | ..... | First appeared γ Andromed Passed betw β and ε Pe and onwards wards the rizon. |
| 9 | 11 18 p.m. | Birmingham ... | =2nd mag.* ..... | White ..... | 0·5 second ... | From χ Persei Cassiopeiæ. |
| 9 | 11 27 p.m. | Ibid ..... | =2nd mag.* ..... | Blue ..... | 0·5 second ... | From ε Ursæ joris to R. A. 1 N. Decl. 43°. |
| 9 | 11 57 p.m. | Ibid ..... | =3rd mag.* ..... | Blue ..... | 0·5 second ... | From γ Piscium R. A. 356°, Decl. 3°. |
| 10 | 0 6 a.m. | Ibid ..... | =3rd mag.* ..... | Blue ..... | 0·5 second ... | From μ Boötis β Herculis. |
| 10 | 0 14 a.m. | Primrose Hill (London). | =1st mag.* ..... | Pale blue ..... | 0·4 second ... | Centre of path below β U Majoris. |
| 10 | 0 21 a.m. | Birmingham ... | =Sirius ..... | Brilliant yellow. | 1 second ..... | From R. A. 2 N. Decl. 24° γ Ophiuchi. |
| 10 | 9 49 p.m. | Ibid ..... | =Sirius ..... | White . ..... | 1 second ..... | From μ Boötis Serpentis. |
| 10 | 9 50 p.m. | Ibid ..... | =3rd mag.* ..... | Blue ..... | 1 second ..... | From α Cor Borealis to Serpentis. |
| 10 | 10 10 p.m. | Ibid ..... | =3rd to 4th mag.* | Blue ..... | 0·5 second ... | From R. A. 3 S. Decl. 1°, Capricorni. |
| 10 | 10 17 p.m. | Ibid ..... | =3rd mag.* ..... | Red ..... | 0·5 second ... | From R. A. 3 N. Decl. 29°, α Pegasi. |
| 10 | 10 19 p.m. | Ibid ..... | =3rd mag.* ..... | Blue ..... | 0·6 second ... | α= From 276° – to 275 – |
| 10 | 10 21 p.m. | Ibid ..... | =2nd mag.* ..... | Blue ..... | 0·5 second ... | From β Aquari R. A. 300°, Decl. 6°. |
| 10 | 10 22 p.m. | Ibid ..... | =1st mag.* ..... | Red ..... | 1 second ..... | From ε Aquilæ R. A. 276°, Decl. 2°. |
| 10 | 10 31 p.m. | Ibid ..... | =1st mag.* ..... | Red ..... | 1½ second ... | From R. A. 2 N. Decl. 54° β Herculis. |
| 10 | 10 40 p.m. | Ibid ..... | =3rd to 4th mag.* | Blue ..... | 0·5 second ... | From α Draconi β Boötis. |
| 10 | 10 52 p.m. | Ibid ..... | =2nd mag.* ..... | Red ..... | 1·5 second; slow motion. | From δ to μ S pentis. |
| 10 | 10 52 15 ,, | Ibid ..... | =3rd mag.* ..... | Blue ..... | 0·5 second ... | From β Boötis t Serpentis. |
| 10 | 10 55 p.m. | Ibid ..... | =1st mag.* ..... | Orange..... | 1 second ..... | From β Draconi π Herculis. |
| 10 | 11 3 p.m. | Ibid ..... | =♃..... | Brilliant white | 1·3 second ... | α= From 327° – to 322 – |

| ırance; Train, if any, ınd its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| ..... | 10° ..... | Directed towards ½ ($\beta$, $\gamma$) Ursæ Minoris. | Radiant, near $\alpha$ Lyræ... | T. Crumplen. |
| a momentary streak ' in length. | 25° ..... | Inclined downwards to left. | The longest flight of the evening. Sky remarkably clear. | Id. |
| a train ..... | ..... | Directed from $\kappa$ Persei.. | ..... | W. H. Wood. |
| ..... | ..... | Directed from Camelopardus. | ..... | Id. |
| ..... | ..... | ..... | ..... | Id. |
| ..... | ..... | ..... | ..... | Id. |
| a broad bluish streak | 10° ..... | Directed from near B Camelopardi. | Meteors scanty for the night. | T. Crumplen. |
| a train ..... | ..... | Directed from K Camelopardi. | Sky overcast ..... | W. H. Wood. |
| ..... | ..... | Directed from H Camelopardi. | Sky clear from $9^h\ 30^m$ p.m. A fine night. | Id. |
| ..... | ..... | Directed from H Camelopardi. | ..... | Id. |
| ..... | ..... | Directed from M Camelopardi. | ..... | Id. |
| a train ..... | ..... | Directed from B Camelopardi. | ..... | Id. |
| ..... | ..... | Directed from P Persei. | ..... | Id. |
| ..... | ..... | ..... | ..... | Id. |
| ..... | ..... | Directed from B Camelopardi. | ..... | Id. |
| ..... | ..... | Directed from $c$ Camelopardi. | ..... | Id. |
| ..... | ..... | Directed from M Camelopardi. | ..... | Id. |
| ft a train ..... | ..... | ..... | ..... | Id. |
| ..... | ..... | Directed from $p$ Camelopardi. | ..... | Id. |
| ..... | ..... | Directed from $b$ Camelopardi. | ..... | Id. |
| he meteor increased from a 2nd mag.e Left a train (?). | ..... | ..... | Rain at $11^h\ 10^m$ p.m. Stars visible in places. | Id. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, α Altitude and Azimuth. |
|---|---|---|---|---|---|---|
| 1866. Aug. 10 | h m 11 4 p.m. | Primrose Hill (London). | =1st mag.*..... | Pale blue ..... | ..... | From D to ½ ( Ursæ Majoris |
| 10 | 11 19 p.m. | Ibid ..... | =1st mag.*..... | Pale blue ..... | ..... | From near ι H culis, passed t way between and e Quadra |
| 10 | 11 31 p.m. | Birmingham ... | =2nd mag.* ..... | Blue ..... | 0·5 second ... | From ε Pegasi Aquarii. |
| 10 | 11 32 p.m. | Ibid ..... | =1st mag.*..... | Blue ..... | 0·5 second ... | From ε Pegasi Aquarii. |
| 10 | 11 39 p.m. | Ibid ..... | =3rd mag.* ..... | Blue ..... | 1 second ..... | From ζ to δ phei. |
| 10 | 11 42 p.m. | Ibid ..... | =Sirius ..... | Yellow ..... | 0·2 second ... | α = From 337° + to 335 + |
| 10 | 11 49 p.m. | Ibid ..... | =Sirius ..... | Brilliant yellow. | 0·75 second ... | From ε Ar medæ to 355°, N. 15°. |
| 10 | 11 54 p.m. | Ibid ..... | =1st mag.*..... | Orange ..... | 1 second ..... | From ν Ar medæ to β gasi. |
| 11 | 0 3 a.m. | Primrose Hill (London). | =♃..... | Vivid pale blue | ..... | Passed from β Minoris to a 10° below Lyræ. |
| 11 | 0 6 a.m. | Birmingham ... | =2nd mag.* ..... | White ..... | 0·5 second ... | From d to a U Majoris. |
| 11 | 0 7 a.m. | Ibid ..... | =3rd mag.* ..... | Blue ..... | 0·75 second ... | From δ to ov Ursæ Maj and 3° beyon |
| 11 | 0 16 a.m. | Ibid ..... | =3rd to 4th mag.* | Blue ..... | 1 second ..... | From the Hea the Lynx t Draconis. |
| 11 | 0 16 a.m. | Primrose Hill (London). | =♃..... | Vivid pale blue | ..... | From η Ursæ noris to i Qu rantis, and ra beyond. |
| 11 | 0 17 a.m. | Ibid ..... | =♃..... | Vivid pale blue | ..... | First appeared Persei. |
| 11 | 0 19 a.m. | Birmingham ... | =Sirius ..... | White ..... | 0·75 second ... | From α Aquilæ R. A. 275°, Decl. 0°. |
| 11 | 0 20 a.m. | Ibid ..... | =2nd mag.* ..... | Red ..... | 1 second ..... | From α Lyræ t Herculis. |
| 11 | 0 21 a.m. | Ibid ..... | =3rd mag.* ..... | Blue ..... | 0·5 second ... | From ξ Draconi ε Herculis. |
| 11 | 0 22 a.m. | Ibid ..... | =3rd mag.* ..... | Blue ..... | 1 second ..... | From ξ Draconi π Herculis. |
| 11 | 0 24 a.m. | Ibid ..... | =2nd mag.* ..... | Blue ..... | 0·5 second ... | From R. A. 31 N. Decl. 7°, Pegasi. |
| 11 | 0 26 a.m. | Ibid ..... | =3rd mag.* ..... | Blue ..... | 0·5 second ... | From ζ Aquari ½ (γ Aquarii Capricorni). |

| eamance; Train, if any, and its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| ..... | 10° or 12°... | Directed from B Camelopardi. | Thunder-storm, and a cloudy sky all the earlier part of the night. | T. Crumplen. |
| a long bright streak.. | 15° ..... | Radiant, $\alpha$ Lyræ..... | Another from the same radiant shortly after. | Id. |
| ..... | ..... | Directed from M Camelopardi. | Rain at $11^h\ 25^m$ p.m. Stars visible in south and in the zenith. | W. H. Wood. |
| a train ..... | ..... | ..... | Sky clearing ..... | Id. |
| a train ..... | ..... | ..... | ..... | Id. |
| a train ..... | ..... | ..... | ..... | Id. |
| a train ..... | ..... | Directed from $c$ Camelopardi. | ..... | Id. |
| a train ..... | ..... | Directed from $\delta$ Persei.. | ..... | Id. |
| ..... | ..... | ..... | Four other meteors about midnight, radiating from B Camelopardi. | T. Crumplen. |
| ..... | ..... | Directed from H Camelopardi. | ..... | W. H. Wood. |
| ..... | ..... | ..... | ..... | Id. |
| ..... | ..... | Conformable to B Camelopardi. | ..... | Id. |
| ft a long and lasting streak, tapering from the centre to the ends. | ..... | Inclined downwards to the left. | ..... | T. Crumplen. |
| ft a long and lasting train, tapering from the centre to the ends. | 20° ..... | Directed towards a point 5° above Capella. | ..... | Id. |
| ..... | ..... | Directed from D Camelopardi. | ..... | Id. |
| ..... | ..... | Directed from $p$ Persei.. | ..... | Id. |
| ..... | ..... | Directed from D Camelopardi. | ..... | Id. |
| ..... | ..... | Directed from $b$ Camelopardi. | ..... | W. H. Wood. |
| ..... | ..... | ..... | ..... | Id. |
| ..... | ..... | Directed from $\delta$ Persei. | ..... | Id. |

| Date. | Hour. | Place of Observation. | Apparent Size. | Colour. | Duration. | Position, Altitude Azimuth |
|---|---|---|---|---|---|---|
| 1866. Aug. 11 | h m s 0 26 15 a.m. | Birmingham ... | = 3rd to 4th mag.* | Blue ..... | 0·5 second ... | From γ Pe R. A. 35 Decl. 8°. |
| 11 | 0 30 a.m. | Ibid ..... | = 1st mag.* ..... | White ..... | 0·5 second ... | From π D to R. A. N. Decl. 5 |
| 11 | 0 31 a.m. | Ibid ..... | = 3rd mag.* ..... | Blue ..... | 1 second ..... | From ε D to ζ Ur noris. |
| 11 | 0 37 a.m. | Ibid ..... | = Sirius ..... | Brilliant white. | 1 second ..... | From ε Aq η Serpenti |
| 11 | 0 38 a.m. | Ibid ..... | = 2nd mag.* ..... | Blue ..... | 1 second ..... | From R. A. S. Decl. 1 δ Aquarii. |
| 11 | 0 42 a.m. | Ibid ..... | = 1st mag.* ..... | Blue ..... | 0·5 second ... | From δ to 1° ε Capricorn |
| 11 | 0 44 a.m. | Ibid ..... | = 1st mag.* ..... | Yellow ..... | 0·5 second ... | From α Delph δ Aquilæ. |
| 11 | 0 44 15 a.m. | Ibid ..... | = 1st mag.* ..... | Blue ..... | 1 second ..... | From λ Pegas Delphini. |
| 11 | 0 51 a.m. | Ibid ..... | Brighter than a 1st mag.* | White ..... | 1 second ..... | From R. A. N. Decl. 50 Capella. |
| 11 | 0 53 a.m. | Ibid ..... | = 1st mag.* ..... | Blue ..... | 1¼ second ... | Path parallel equal to the Distance a ½°. |
| 11 | 0 59 a.m. | Ibid ..... | = 1st mag.* ..... | White ..... | 0·5 second ... | From R. A. N. Decl. 28° R. A. 44°, Decl. 19°. |
| 11 | 1 0 a.m. | Ibid ..... | = 2nd mag.* ..... | Blue ..... | 0·75 second ... | From R. A. N. Decl. 28°, R. A. 47°, Decl. 13°. |
| 16 | 10 5 p.m. | Nærö-Fiord, Norway. N. lat. 60° 58′, W. long. 6° 50′. | Brighter than a 1st mag.* | Nearly white.. | ..... | From R. A. 8h 4 N. Decl. 69°, R. A. 7h 30m, Decl. 65°. |
| 20 | 9 16 p.m. | Bergen, Norway | = 2nd to 3rd mag.* | Yellow ..... | ..... | Disappeared nea Persei. |
| 25 | About 7 45 p.m. | Hawkhurst (Kent). | Nearly = 1 ..... | White ..... | 2 seconds..... | Centre of path west of, and the same level the moon. |
| Sept. 1 | 10 29 p.m. | Sunderland ..... | = 3rd mag.* ..... | Yellow ..... | Very quick ... | Path 2° below Ursæ Minoris. |

| ·ince; Train, if any, id its Duration. | Length of Path. | Direction; noting also whether Horizontal, Perpendicular, or Inclined. | Remarks. | Observer. |
|---|---|---|---|---|
| ..... | ..... | Directed from D Camelopardi. | ..... | W. H. Wood. |
| train ..... | ..... | Directed from K Camelopardi. | ..... | Id. |
| ..... | ..... | ..... | ..... | Id. |
| train ..... | ..... | Directed from $\delta$ Persei.. | ..... | Id. |
| ..... | ..... | Directed from $\gamma$ Persei.. | ..... | Id. |
| ..... | ..... | Directed from $\gamma$ Persei.. | ..... | Id. |
| train ..... | ..... | ..... | ..... | Id. |
| ..... | ..... | ..... | ..... | Id. |
| ..... | ..... | Directed from H Camelopardi. | ..... | Id. |
| ..... | ..... | Directed from H Camelopardi. | Began and ended about 1° higher than the last (see fig.). | Id. |
| ..... | ..... | ..... | ..... | Id. |
| ..... | ..... | Conformable to B Camelopardi. | Sky overcast at $1^h\ 15^m$ a.m. Nights of the 11th and 12th overcast. | Id. |
| ..... | ..... | ..... | ..... | T.W. Backhouse. |
| ..... | | | | |
| a yellow train 1° ng, 3° or 4° above e place of disappearance for one or two econds. | ..... | Downwards ..... | The train was as bright as the head. | Id. |
| ake of light ..... | 12° ..... | Perpendicular ..... | Seen through hazy clouds. | A. S. Herschel. |
| ..... | ..... | ..... | ..... | T.W. Backhouse. |
| .....  | | | | |

Supplement to Catalogue.—Observations of Luminous

| No. | 1865, Nov. 13th A.M., G. M. T. | Magnitude as per stars. | Apparent point of commencement. | | Apparent point of commencement from globe. | | Direction by hour of imaginary dial; 12 hour vertical. |
|---|---|---|---|---|---|---|---|
| | | | Azimuth W. from S. | Altitude. | R. A. | N. P. D. | |
| | h m s | | ° ′ | ° ′ | h m | ° ′ | h |
| 1. | 12 9 0 | 1 | 244 55 | 44 9 | 8 35 | 43 30 | 7½ |
| 2. | 10 8 | 2 | 11 35 | 62 40 | 3 19 | 64 20 | 4 |
| 3. | 11 32 | 2 | 292 35 | 46 59 | 6 33 | 66 20 | 2½ |
| 4. | 13 38 | 2 | 276 5 | 26 29 | 6 37 | 52 40 | 3 |
| 5. | 14 4 | 2 | 116 35 | 55 9 | 23 52 | 36 20 | 8 |
| 6. | 14 41 | 1 | 274 35 | 46 29 | 7 24 | 57 40 | 7½ |
| 7. | 15 1 | 2 | 115 35 | 44 9 | 22 53 | 43 30 | 8 |
| 8. | 17 6 | ... | 187 35 | 19 9 | 14 47 | 31 10 | 8½ |
| 9. | 17 21 | 3 | 339 35 | 34 9 | 4 54 | 90 0 | 3 |
| 10. | 18 30 | 3 | 47 35 | 46 9 | 2 36 | 73 20 | 6 |
| 11. | 21 8 | 2 | 223 35 | 19 39 | 10 59 | 53 0 | 9 |
| 12. | 21 35 | 2 | 223 35 | 19 39 | 10 59 | 53 0 | 9 |
| 13. | 22 3 | 2 | 76 35 | 36 39 | 0 0 | 68 20 | 5 |
| 14. | 23 56 | 2 | 232 5 | 16 9 | 11 53 | 48 30 | 8½ |
| 15. | 25 20 | 1 | 263 5 | 39 9 | 9 35 | 55 10 | 12 |
| 16. | 25 25 | 3 | 51 35 | 21 9 | 0 48 | 93 50 | 4 |
| 17. | 27 55 | 3 | 75 35 | 52 9 | 1 2 | 58 20 | 4 |
| 18. | 28 19 | 2 | 42 5 | 43 9 | 1 30 | 74 20 | 4 |
| 19. | 30 11 | 3 | 9 35 | 43 39 | 3 31 | 83 40 | 3 |
| 20. | 31 2 | 3 | 236 5 | 15 59 | 11 3 | 57 10 | 8½ |
| 21. | 33 24 | 3 | 242 5 | 27 39 | 10 29 | 50 20 | 5 |
| 22. | 34 26 | 3 | 335 35 | 42 9 | 5 21 | 87 50 | 4 |
| 23. | 34 41 | 1 | 165 5 | 19 9 | 17 45 | 35 10 | 8 |
| 24. | 40 17 | 3 | 1 5 | 30 39 | 3 55 | 96 0 | 5 |
| 25. | 42 10 | 2 | 160 35 | 37 9 | 19 54 | 22 20 | 7 |
| 26. | 43 27 | 3 | 211 5 | 18 39 | 13 4 | 41 30 | 8½ |
| 27. | 43 28 | 2 | 26 35 | 26 39 | 2 40 | 97 30 | 5 |
| 28. | 44 30 | 4 | 276 5 | 14 9 | 9 22 | 83 0 | 4½ |
| 29. | 46 2 | 1 | 296 35 | 44 39 | 7 14 | 68 30 | 2½ |
| 30. | 46 27 | 2 | 177 35 | 42 9 | 16 56 | 10 12 | 9 |
| 31. | 46 33 | 3 | 191 5 | 54 9 | 8 53 | 6 55 | 6 |
| 32. | 47 21 | 3 | 191 5 | 54 9 | 8 54 | 6 55 | ... |
| 33. | 47 25 | 3 | 42 5 | 42 9 | 2 17 | 78 50 | 4 |
| 34. | 51 41 | 2 | 266 5 | 20 9 | 9 45 | 71 40 | 4 |
| 35. | 53 35 | 3 | 332 35 | 29 9 | 6 4 | 94 20 | 5 |
| 36. | 54 8 | 2 | 151 35 | 50 9 | 22 38 | 18 40 | 7 |
| 37. | 54 25 | 2 | 332 5 | 42 39 | 5 44 | 82 10 | 4 |
| 38. | 54 41 | 4 | 215 5 | 42 9 | 11 7 | 26 10 | 8½ |
| 39. | 56 10 | 2 | 159 35 | 23 39 | 18 50 | 32 10 | 8 |
| 40. | 58 44 | 3 | 292 35 | 21 39 | 8 28 | 85 40 | 4½ |
| 41. | 59 50 | 3 | 213 20 | 19 54 | 11 7 | 58 20 | 8½ |
| 42. | 1 0 25 | 1 | 127 20 | 49 9 | 23 38 | 33 30 | 3 |
| 43. | 0 48 | 2 | 10 5 | 22 9 | 3 45 | 103 0 | ... |
| 44. | 1 1 | 1 | 30 35 | 20 9 | 2 35 | 102 20 | ... |
| 45. | 2 9 | 1 | 147 35 | 8 39 | 19 30 | 51 50 | 7½ |
| 46. | 3 0 | 3 | 13 35 | 27 9 | 3 47 | 98 20 | 4 |
| 47. | 5 27 | 1 | 236 55 | 30 29 | 10 57 | 46 30 | 9 |
| 48. | 5 27 | 3 | 108 35 | 65 9 | 1 53 | 37 30 | 7½ |
| 49. | 6 33 | 3 | 322 5 | 24 9 | 6 56 | 96 0 | 4 |
| 50. | 6 34 | 3 | 330 35 | 19 9 | 6 31 | 103 40 | 4½ |

leteors at the Observatory, Cambridge, 1865, Nov. 13th, A.M.

| No. | Direction referred to an hour-circle through the pole (0°), round the circle through the W. | Notes. | Observer. | References. |
|---|---|---|---|---|
| | ° ′ | | | |
| 1. | 286 10 | Left a train | J. C. Adams. | |
| 2. | 112 5 | | A. Graham. | |
| 3. | 105 35 | Left a train | J. C. Adams | No. 3, identical with Hawkhurst, $12^h\ 11^m\ 30^s$ A.M. See Appendix IV. 2. |
| 4. | 142 40 | Left a train | Id. | |
| 5. | 172 50 | Left a train | A. Graham. | |
| 6. | 263 50 | Left a train | J. C. Adams. | |
| 7. | 186 40 | | A. Graham. | |
| 8. | 273 16 | | J. C. Adams. | |
| 9. | 102 20 | | H. Graham. | |
| 10. | 151 50 | | A. Graham. | |
| 11. | 309 50 | Left a slight train | J. C. Adams. | |
| 12. | 309 50 | Left a slight train | Id. | |
| 13. | 110 10 | Left a train | A. Graham. | |
| 14. | 295 10 | Left a very short train | J. C. Adams. | |
| 15. | 47 50 | | Id. | |
| 16. | 91 16 | Left a slight train | H. Graham. | |
| 17. | 75 50 | | A. Graham. | |
| 18. | 94 50 | | H. Graham. | |
| 19. | 84 6 | | Id. | |
| 20. | 299 50 | | J. C. Adams. | |
| 21. | 194 40 | | Id. | |
| 22. | 134 40 | | H. Graham. | |
| 23. | 224 5 | | J. C. Adams. | |
| 24. | 149 20 | | H. Graham. | |
| 25. | 177 20 | Positions doubtful | J. C. Adams. | |
| 26. | 283 30 | | Id. | |
| 27. | 133 55 | | A. Graham. | |
| 28. | 172 50 | As bright as Jupiter; fine train | J. C. Adams. | |
| 29. | 103 30 | | Id. | No. 29, identical with Hawkhurst, $12^h\ 46^m$ A.M. See Appendix IV. 2. |
| 30. | 261 36 | Left a short train. Nos. 30–32 computed R.A. and N.P.D. | A. Graham. | |
| 31. | 281 45 | | Id. | |
| 32. | ..... | | Id. | |
| 33. | 95 20 | | H. Graham. | |
| 34. | 160 10 | | J. C. Adams. | |
| 35. | 166 25 | | H. Graham. | |
| 36. | 144 30 | | A. Graham. | |
| 37. | 136 50 | | H. Graham. | |
| 38. | 313 30 | As bright as Jupiter; fine train | J. C. Adams. | |
| 39. | 216 20 | Left a short train | A. Graham. | |
| 40. | 169 30 | | J. C. Adams. | |
| 41. | 302 30 | | Id. | |
| 42. | 28 10 | Moved slowly through 5° of arc. | A. Graham. | |
| 43. | ..... | | H. Graham. | |
| 44. | ..... | | Id. | |
| 45. | 201 20 | | A. Graham. | |
| 46. | 111 35 | | H. Graham. | |
| 47. | 315 0 | Left a train | J. C. Adams. | |
| 48. | 152 20 | | A. Graham. | |
| 49. | 142 20 | | H. Graham. | |
| 50. | 153 0 | Rough positions | Id. | |

Observations of Luminous Meteors at the

| No. | 1865, Nov. 13th, A.M., G. M. T. | Magnitude as per stars. | Apparent point of commencement. | | Apparent point of commencement from globe. | | Direction by hour of imaginary dial: 12 hour vertical. |
|---|---|---|---|---|---|---|---|
| | | | Azimuth W. from S. | Altitude. | R.A. | N. P. D. | |
| | h m s | | ° ′ | ° ′ | h m | ° ′ | h |
| 51. | 1 6 47 | 2 | 213 20 | 45 9 | 11 3 | 23 20 | 9½ |
| 52. | 7 21 | 3 | 51 5 | 24 9 | 1 30 | 94 10 | 4½ |
| 53. | 8 36 | 1 | 30 35 | 51 39 | 3 25 | 72 40 | 5 |
| 54. | 10 22 | 3 | 50 5 | 21 41 | 1 41 | 94 0 | 4½ |
| 55. | 10 34 | 1 | 65 5 | 19 9 | 0 49 | 89 40 | 4 |
| 56. | 11 51 | 2 | 219 35 | 28 9 | 12 16 | 37 53 | 8½ |
| 57. | 12 4 | 3 | 19 35 | 28 9 | 3 30 | 97 10 | 4½ |
| 58. | 13 8 | 1 | 137 35 | 49 9 | 23 30 | 28 50 | 7½ |
| 59. | 13 44 | 3 | 187 5 | 53 9 | 9 42 | 4 24 | 5½ |
| 60. | 14 40 | 3 | 5 5 | 30 12 | 6 0 | 96 20 | 4½ |
| 61. | 14 40 | 2 | 33 5 | 53 9 | 3 28 | 71 20 | 4½ |
| 62. | 15 12 | 1 | 190 35 | 28 9 | 15 10 | 25 20 | 8½ |
| 63. | 16 25 | 1 | 183 35 | 13 9 | 16 26 | 39 30 | 9 |
| 64. | 16 39 | 2 | 321 5 | 22 9 | 7 8 | 98 0 | 4 |
| 65. | 18 5 | 3 | 147 5 | 55 39 | 0 20 | 19 29 | 7 |
| 66. | 18 27 | 3 | 303 5 | 20 9 | 8 20 | 92 20 | 4 |
| 67. | 18 5 | 2 | 180 0 | 52 13 | ..... | 0 0 | 8 |
| 68. | 23 34 | ... | 348 5 | 62 14 | 5 15 | 64 40 | 1 |
| 69. | 24 11 | 1 | 63 35 | 37 39 | 1 46 | 74 20 | 5 |
| 70. | 24 55 | 1 | 240 35 | 39 9 | 10 25 | 44 50 | 10 |
| 71. | 25 6 | ... | 53 5 | 28 39 | 2 3 | 87 30 | ... |
| 72. | 26 32 | 1 | 112 5 | 42 9 | 0 0 | 46 20 | 6 |
| 73. | 27 29 | 2 | 227 5 | 18 29 | 12 30 | 55 20 | 8½ |
| 74. | 28 16 | 1 | 191 35 | 58 9 | 7 51 | 8 52 | 7½ |
| 75. | 27 37+ | 1 | 46 35 | 52 9 | 2 50 | 66 0 | 5 |
| 76. | 29 54 | 1 | 196 5 | 46 54 | 12 45 | 12 0 | 8½ |
| 77. | 30 20 | 3 | 317 42 | 26 9 | 5 45 | 100 0 | 4 |
| 78. | 31 22 | 2 | 28 5 | 32 9 | 3 30 | 92 0 | 4 |
| 79. | 32 15 | 2 | 172 35 | 19 9 | 15 5 | 34 0 | 8 |
| 80. | 33 32 | 2 | ..... | ..... | ..... | ..... | 4½ |
| 81. | 33 44 | 2 | 46 35 | 29 9 | 2 30 | 89 0 | 4 |
| 82. | 34 50 | 2 | 349 35 | 61 39 | 5 28 | 66 0 | 4 |
| 83. | 36 28 | 2 | 229 35 | 25 9 | 12 24 | 44 50 | 8½ |
| 84. | 38 7 | 1 | 134 35 | 16 9 | 21 0 | 51 0 | ... |
| 85. | 38 22 | ... | 47 5 | 23 9 | 2 20 | 93 40 | 4 |
| 86. | 39 55 | 3 | 165 35 | 47 9 | 22 8 | 12 0 | 7 |
| 87. | 41 24 | 3 | 101 35 | 39 9 | 0 29 | 54 0 | 6 |
| 88. | 41 27 | 3 | 181 5 | 38 39 | 18 0 | 34 0 | 8 |
| 89. | 42 2 | 2 | 300 5 | 35 9 | 8 23 | 77 40 | 7 |
| 90. | 43 40 | 2 | 209 5 | 32 39 | 13 30 | 28 20 | ... |
| 91. | 43 46 | 3 | 83 5 | 24 9 | 0 33 | 75 0 | 4 |
| 92. | 43 51 | 3 | 100 35 | 53 39 | 1 37 | 43 40 | 8 |
| 93. | 43 53 | 3 | 31 5 | 20 9 | 3 15 | 102 0 | 8 |
| 94. | 46 5 | 1 | 51 35 | 19 9 | 2 0 | 96 0 | 5 |
| 95. | 46 51 | 1 | 82 35 | 20 9 | 0 30 | 79 0 | 4½ |
| 96. | 49 2 | 1 | 34 35 | 32 9 | 3 23 | 90 0 | 4½ |
| 97. | 51 5 | 2 | 134 5 | 19 39 | 21 55 | 49 0 | 7 |
| 98. | 52 19 | 1 | 153 5 | 14 9 | 20 7 | 44 0 | 8 |

)bservatory, Cambridge (*continued*).

| No. | Direction referred to an hour-circle through the pole (0°), round the circle through the W. | Notes. | Observer. | References. |
|---|---|---|---|---|
| | ° ′ | | | |
| 51. | 343 10 | ..... | J. C. Adams. | |
| 52. | 106 30 | ..... | A. Graham. | |
| 53. | 119 50 | Motion very slow ..... | Id. ..... | No. 53, identical with Hawkhurst, $1^h\ 8^m\ 45^s$ A.M. |
| 54. | 106 55 | ..... | H. Graham. | See Appendix IV. 2. |
| 55. | 86 10 | Left a train ..... | A. Graham. | |
| 56. | 292 53 | ..... | J. C. Adams. | |
| 57. | 123 10 | ..... | H. Graham. | |
| 58. | 166 0 | Left a short train ..... | A. Graham. | |
| 59. | 271 58 | ..... | J. C. Adams. | |
| 60. | 131 52 | Left a fine train ..... | H. Graham. | |
| 61. | 114 20 | Left a train ..... | A. Graham. | |
| 62. | 262 45 | ..... | J. C. Adams. | |
| 63. | 273 27 | Rough observation ..... | Id. | |
| 64. | 152 0 | Left a train ..... | H. Graham. | |
| 65. | 123 39 | ..... | A. Graham. | |
| 66. | 150 55 | Left a short train ..... | H. Graham. | |
| 67. | ..... | Through North Pole ..... | J. C. Adams. | |
| 68. | 38 0 | ..... | H. Graham. | |
| 69. | 115 20 | Left a train ..... | A. Graham. | |
| 70. | 349 10 | Left a train ..... | J. C. Adams ..... | No. 70, identical with Hawkhurst, $1^h\ 24^m\ 45^s$ A.M. |
| 71. | ..... | ..... | H. Graham. | See Appendix IV. 2. |
| 72. | 128 20 | ..... | A. Graham. | |
| 73. | 280 30 | ..... | J. C. Adams. | |
| 74. | 1 34 | Computed R. A. and N. P. D. | A. Graham. | |
| 75. | 120 50 | Left a fine train ..... | H. Graham ..... | No. 75, identical with Hawkhurst, $1^h\ 28^m\ 15^s$ A.M. |
| 76. | 309 30 | Left a train ..... | J. C. Adams. | See Appendix IV. 2. |
| 77. | 127 35 | ..... | H. Graham. | |
| 78. | 103 15 | ..... | Id. | |
| 79. | 231 50 | ..... | J. C. Adams. | |
| 80. | ..... | Through Polaris ..... | A. Graham. | |
| 81. | 93 35 | Left a train ..... | H. Graham. | |
| 82. | 126 55 | Left a train ..... | A. Graham. | |
| 83. | 289 0 | ..... | J. C. Adams. | |
| 84. | ..... | A flash ..... | A. Graham. | |
| 85. | 93 20 | ..... | Id. | |
| 86. | 162 50 | ..... | Id. | |
| 87. | 132 10 | ..... | Id. | |
| 88. | 241 11 | ..... | J. C. Adams. | |
| 89. | 242 50 | Left a short train ..... | H. Graham. | |
| 90. | 278 55 | ..... | J. C. Adams. | |
| 91. | 201 0 | Rough observation ..... | A. Graham. | |
| 92. | ..... | ..... | Id. | |
| 93. | 101 10 | Left a train ..... | H. Graham. | |
| 94. | 106 10 | ..... | Id. | |
| 95. | 111 55 | ..... | A. Graham. | |
| 96. | 114 35 | Left a train ..... | Id. | |
| 97. | 174 25 | Left a train ..... | H. Graham. | |
| 98. | 216 30 | Left a short train ..... | A. Graham. | |

## APPENDIX.

### I. Meteors doubly observed.

(1.) 1865, September 24th, $7^h\ 8^m\ 45^s$ P.M., G. M. T.

The meteor observed at Greenwich, Ramsgate, and Hawkhurst (see Catalogue), commenced its course sixty-seven miles above the coast of France, in the zenith of a place in N. lat. 49° 57′, E. long. 2° 12′, and disappeared thirty-eight miles above the English Channel, in N. lat. 50° 26′, E. long. 0° 23′. Path ninety-one miles in four seconds, directed from a point in R. A. 2°, N. Decl. 2°, near the first point of Aries. Velocity twenty-three miles per second. The meteor is a good example, triply observed, of the group of meteors directed from the radiant in Pisces or Cetus, described in the Monthly Notices of the Royal Astronomical Society for December 9th, 1864.

(2.) 1865, September 24th, $8^h\ 30^m$ P.M., G. M. T.

The meteor observed at Greenwich and at Manchester, at Frome in Devonshire, and at Winchfield in Hants, commenced its course thirty-four miles in the zenith of a place seven miles east of Bath, and disappeared thirty miles above a point four miles south of Gloucester.

The course of the meteor, prolonged onwards, would nearly touch Manchester, where it was seen to descend with a slight inclination, and a short course in the S.S.W. This observation necessitates a small correction. The course appears actually to have been from thirty-eight miles over Bath to twenty-seven miles over Gloucester. Velocity twenty-four miles per second. Path thirty-six miles in $1\frac{1}{2}$ second, directed from some part of the constellation Capricornus, not far from a point in right ascension $20^h$, south declination 30°, described by Dr. Neumayer, at Melbourne, as a point of the highest interest, and deserving particular attention with the view of determining further points of radiation.

(3.) 1865, September 26th, $8^h\ 55^m$ P.M., G. M. T.

The meteor observed at Thirsk, in Yorkshire, and at Hawkhurst, commenced its course about 107 miles above a part of the North Sea, in N. lat. 54° 55′, E. long. 2° 43′, and disappeared seventy-six miles above the neighbourhood of Sheffield. Path 200 miles in $3\frac{1}{2}$ seconds. Velocity fifty-seven miles per second. Direction from a point near Auriga, in right ascension 69°, north declination 25°. This meteor is one of a group of meteors directed from a radiant in Auriga, described in the last-mentioned Number of the Monthly Notices of the Royal Astronomical Society. It appears from this No., and from No. 1 of this Appendix, that the velocity of the meteors from Auriga is nearly three times as great as that of the meteors directed from Cetus or Pisces.

(4.) 1865, September 26th, $9^h\ 21^m$ P.M., G. M. T.

Notes of the meteor, seen by Mr. Harding, of the Royal Observatory, Greenwich, on the evening of the 26th of September last, were received, first, from Eastbourne, and second, from Weston-super-Mare, in Somersetshire. Over the latter county it appears to have attained its greatest brilliancy; but at what altitude above the earth can only be roughly estimated from the observation at Eastbourne, compared with that near Greenwich. The height indicated is from about fifty to about thirty miles above the surface of the earth. The radiant-point, or direction of its flight, was from about the position of Polaris, a region from which a wide group of meteors take their course in

a remarkably definite manner during the month of August, and more especially in September.

(5.) 1865, November 13th, $5^h\ 42^m$ P.M., G. M. T.

The following account of the meteor is communicated by Mr. T. Crumplen. "When first seen, it had the appearance of a star of the 3rd magnitude, rapidly increasing in splendour until its maximum light was at least equal to three times that of the planet Venus. Numerous sparks were thrown off as it passed along, the nucleus exploding just before it disappeared. Its flight was certainly retarded during its passage; it was visible over a large area, observations having reached me from places as widely separated as Boulogne and Market-Drayton.

"From these I conclude that the meteor was first seen about eighty miles in the zenith of a place midway between Aylesbury and Stoney Stratford, moving in a W.S.W. direction, passing south of Cirencester and just north of Cleveland, ending about the same height over Hartley Quay—a path of some 165 miles in $2\frac{1}{2}$ seconds. The velocity is certainly very great—sixty-six miles per second; but I am convinced that it was not less. This will serve for a sufficient indication of the height of these meteors, which we must consider to be part of the great November zone."

The height and velocity are both above the average. It should be borne in mind that small errors of observation may sometimes lead to exaggerated estimates, both of the height and velocity of a meteor's flight.

(6.) 1865, November 18th, $4^h\ 30^m$ P.M.

The appearance of the meteor seen in twilight by Mr. F. C. Penrose at Wimbledon, is also announced from Cambridge (see Catalogue) among the list of meteor-observations for November, communicated by Mr. T. Crumplen. Particulars of the apparent path of this meteor at other places, if they can still be obtained, would lead to determining its real height and velocity, and of what meteoric shower the fireball formed a part.

(7.) 1865, November 21st, $6^h\ 5^m$ P.M., G. M. T.

The eastern coast of England is for the third time visited by a detonating meteor of large size, within a day before or after the date of the 20th November (*v.* Report, 1865, p. 121). For the means of ascertaining its direct distance from the earth, the path that it pursued, its velocity, &c., the Committee are mainly indebted to the accounts collected from distant places by Mr. Warren De la Rue, by whom the meteor was observed near Cranford. It was also seen, and the position of its point of disappearance was noted by Mr. F. C. Penrose, F.R.A.S., at Wimbledon. A loud report like that of a cannon followed its disappearance, at an interval of 2 minutes and 20 seconds. The meteor was observed by the Assistant at the Observatory of Cambridge, Mr. H. C. Todd, and at Oxford and at Liverpool, as well as at other places more near to the seat of the explosion, which was over the Thames valley. The meteor traversed the entire length of the valley of the Thames, a distance of about seventy-five miles, from the Nore (height about forty-one miles) to Henley-on-Thames (height twenty-seven miles) in $6\frac{1}{2}$ seconds, at a velocity, therefore, of about eleven and a half miles per second. Sound, with its ordinary velocity in common air, would take 2 minutes 50 seconds to traverse the distance from the latter point to the station where Mr. Penrose observed the meteor at Wimbledon. The direction of the meteor was from a point in the neighbourhood of the constellation Taurus, between Taurus and the head of Cetus.

The meteor of the 19th November, 1861 (*v.* Report 1862, p. 79), as seen at Woodford, at first appeared stationary for two seconds at a point in Cetus. The epoch of the 19th—21st November accordingly deserves attention, partly as one for which the direction of the detonating meteors has been ascertained, and partly because their frequent returns within very narrow limits of time about that date makes it probable that, like the meteors of the 10th of August and 13th of November, they exist as a group of bodies revolving in a fixed orbit round the sun.

(8.) 1866, January 6th, $9^h\ 59^m$ P.M., G. M. T.

The meteor seen and recorded at the Royal Observatory, Greenwich, approaches nearly in time and general description to that recorded at Sunderland and at Wisbeach. It is, however, distinct; and the radiant-region L H roughly represents the general direction of the two meteors, which was from between Leo Minor and the Head of Leo.

(9.) 1866, January 11th, $9^h\ 55^m$ P.M., Greenwich time.

A meteor of very extraordinary length of path, generally observed in England. Referred to the stars at Bedford, and at Hay (S. Wales), the visible path appears to have been either truly horizontal, or otherwise slightly inclined a little upwards, the meteor performing its transit at a height of eighty-five to ninety-five miles above the earth. The direction of flight was from E.S.E. to W.N.W., on a direct line from Paris to Cork, but *probably extending beyond the limits of either of those places* at the beginning and end of its luminous track. Assuming the distance of the meteor from Ticehurst to have been only fifty miles (instead of ninety, as inferred from the other observations), the altitudes (as measured at Ticehurst) of 15° at first appearance in the east, and 10° at disappearance in the west, give not less than 450 miles as the length of the meteor's course. Half as long again as this, or nearly 700 miles, would not be an exaggerated statement of the extravagant length of path of this, certainly, very remarkable meteor. It may be compared in this respect to the meteor of 1758, described by Pringle, and to the meteor of the 18th of August, 1783. The meteor observed at the Greenwich Observatory about the same time, or two minutes earlier, is distinct, and crosses the path of the other at an angle. Both meteors were directed from a radiant region L H, near the confines of Leo and Hydra.

(10.) 1866, June 20th, $10^h\ 45^m$ A.M., Greenwich time (see Appendix II. 6).

Notwithstanding this great aërolitic meteor appeared by day and in bright sunshine, exact observations of its apparent path were obtained at Ticehurst by the schoolmaster of the village, Mr. R. Covington, and at Boulogne, by Mr. F. Galton, the Secretary of the Royal Geographical Society. Instrumental measurements at those places show that the meteor first came into sight at a distance of fifteen miles above the town of Calais, and that when it disappeared near Boulogne (about midway between that town and the town of Montreuil, in Somme) its distance from the earth was only four and a half miles. The following statement which appeared in a daily journal, if correct, shows the violence of the shock which was felt at Boulogne. "The vibration caused by the explosion at that place was so great that an ill-constructed scaffolding fell to the ground, and one man at work upon the scaffolding was killed, and another seriously injured by the fall."

Although the meteor was of unusual dimensions, no meteorites are reported to have been found.

## II. Large Meteors.

### (1.) 1768, December 23rd, 7h A.M. (local time).

A very clear description* of the phenomenon attending the fall of a meteorite appears in the account of Cook's Voyage round the World, published under the title of "A Voyage round the World in His Majesty's Ship Endeavour, in the years 1768–71 (London, 1771)." Professor Miller, of Cambridge, who communicates the extract, accompanies it with the remark that "the passage must have escaped the notice of Mr. Greg, and of all other meteor historiographers."

Page 25, for Date and Place.—"Thursday, Dec. 8, 1768, having procured all necessary supplies, we left Rio Janeiro, etc."

Page 26, "December 23rd we observed an eclipse of the moon; and about 7 o'clock in the morning a small white cloud appeared in the west, from which a train of fire issued, extending itself westerly: about two minutes after we heard two distinct loud explosions, immediately succeeding each other like cannon, after which the cloud soon disappeared."

### (2.) 1861, March 4th, 9h 38m 30s A.M., Melbourne mean time. (Results of Meteorol. Observations in Victoria, S. Australia, 1858–62, by Dr. G. Neumayer; p. 141.)

A large meteor in bright daytime, seen in nearly the whole S.E. part of Australia. The meteor was seen at sea, on board of the 'Constance,' thirty miles S.W. of the Otway.

From the measurements of Captain Sörderbergh, and from various observations made throughout the country, Dr. Neumayer adduces the following facts relative to the occurrence :—

| | miles. |
|---|---|
| Height of the meteor above the earth when first seen .. | 54·6 |
| Height of the meteor above the earth when bursting .. | 10·0 |
| Distance from Colar when first seen ..... | 77·2 |
| Distance from Colar when bursting ..... | 73·0 |

Diameter 0·18 mile, or 1190 feet.

No mention is made by Dr. Neumayer of any detonation having been heard.

### (3.) 1865, December 7th, 7h 20m P.M., G. M. T.
### (Paris Observatory Bulletins, Jan. 5th and 6th, 1866.)

A fireball exploded at a height of thirty-eight miles over the mouth of the Loire with a report likened to that of a cannon fired off at a distance of a few miles (at Vannes), and to a slight shock of an earthquake at La Roche-Bernard. The meteor was visible over an extent of the coast from Brest to Bordeaux, whence M. Gruey obtains from observations the following approximate elements of its path. The meteor proceeded, from a point about fifty-five miles above the sea at Quimper, descending at an inclination of about 15° from horizontal towards the E.S.E., a distance of eighty miles in 15 or 20 seconds, to the point of its explosion, thirty-five miles above the mouth of the Loire. Velocity not less than ten miles per second.

The diameter is reckoned by M. Gruey at 180 yards, but it is added that the effect of irradiation would be to considerably diminish this amount.

No meteorites were discovered, although the explosion was considerable, and the size and the luminosity of the fireball were quite unusual.

* The punctuation is strictly given as in the original. The passage is also found in Barrow's small edition of Cook's Voyages. A. and C. Black, Edinb., 1860, p. 19.

(4.) 1865, December 9th, $8^h\ 30^m$ P.M. (local time).

At Charleston, South Carolina, U.S., the sky being overcast and a slight rain falling, but unattended by thunder or lightning, a brilliant and strong light was for a moment perceived. A sentinel walking his rounds was enabled by the light to detect a boat with two persons leaving the fort, and by levelling his piece to oblige it to return. Half a minute or a minute afterwards, an explosion, and a loud jarring sound were heard; the fireball itself, if such was the nature of the phenomenon, was hidden by clouds.

(5.)* 1866, March 11th, $0^h\ 20^m$ A.M. local time:—
(March 10th, $11^h\ 50^m$ P.M., G.M.T.)

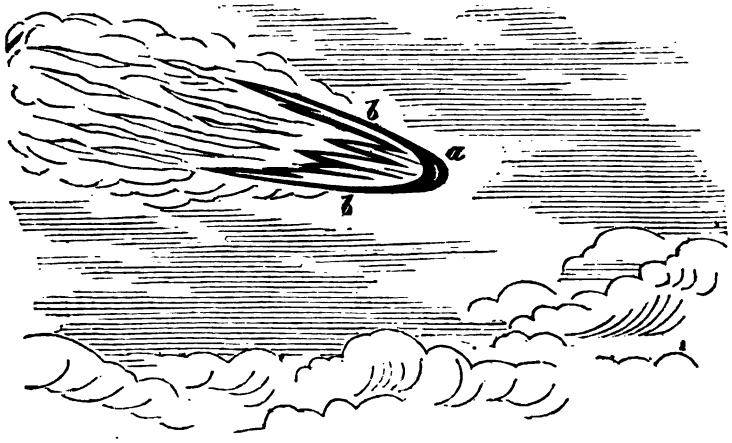
A yellow or reddish fireball, half the apparent size of the full moon, followed by a broad train of dull red colour, exploded into fragments near Lübbecke (forty miles east from Münster) with a report loud enough to be plainly heard at Münster. People at Lübbecke were awakened from their sleep; the report was likened to a discharge of artillery followed by that of musketry, and by a rushing sound like the arrival of a railway train. The light was sufficient to have counted money: the meteor, as drawn by Professor Heis upon a map, was visible in the surrounding districts of Lübbecke, Westphalia, and Hanover.

It commenced its course at a height of thirteen miles (British) above Miete, terminating at three-and-a-half miles (British) over Oldendorf in Lübbecke. Path, thirty miles in four to five seconds, directed from azimuth W. from S. 50°, altitude 20°; velocity seven miles per second. At Lübbecke the report succeeded its disappearance in little more than a quarter of a minute. No meteorite in the neighbourhood is reported to have fallen.

(6.) 1866, June 20th, $10^h\ 45^m$ A.M., G.M.T.

1. As observed at Penshurst.

Dear Sir,—In case you should not have seen the great meteor of $10^h\ 45^m$ A.M., June 20th 1866, I send you a rude sketch of the appearance as seen by




The Great Meteor, as seen from Penshurst, $10^h\ 45^m$ A.M., June 20, 1866.
(Elevation 30°. Direction of flight from N.N.E. to S.E.—Jas. Nasmyth.)

* A Pamphlet by Prof. Heis, with map of meteor's course (8vo. Halle, 1866, H. W. Schmidt).

me from here. I had a fine view of it for about two seconds as it skimmed majestically across a bright blue portion of the sky, which was in other parts covered by white clouds. I heard no sound, although I listened very attentively for it; but the wind was blowing through the trees, and so might have drowned the sound to me.

The brilliant orange-red with rose tint on the after part (*b*), and bright white light at the forward end (*a*), gave it a most wonderful aspect when surrounded by the blue sky.

The drawing, although roughly made, is, I may say, generally faithful.

The elevation was about 30°; the inclination of the axis, about 5°; the length of the strikingly visible portion, about 1° 30′; the white vapour veil, perhaps 8° or 10° long, but, as it faded very gradually, one could not assign an exact length to *it*. The red tail appeared to flame and flicker considerably.

If it had made its transit *at night*, it would have lit up the whole of England; but such a meteor seen in bright sunshine gives it a very special character of interest.

I am, &c., JAS. NASMYTH.

*Penshurst, June 22nd*, 1866.
*To A. S. Herschel, Esq.*

2. As seen at Brighton. (From Mr. Galton's MS.)

"We saw T. point behind us; we turned, and saw a thing like a comet passing through the air; a bright ball of fire with a bright tail was what it looked like. As it got near the cliff which lies to the east, it got smaller and then vanished into space. Some people heard it go off like a gun when it disappeared. T. says it was much larger at first; it went fast and *straight across* between us and the town.

"A meteor passed over Brighton at 10½ A.M. on June 20th; it came from N.W. and travelled rapidly, and disappeared S.S.E. The policeman on Kemp Town slopes described it as shaped like a ginger-beer bottle; one half of the bottle was a strong blood-red light, the other half of the body was like a thin white vapour, and the extremity of the object was a thin white cloud like a comet's tail, but not luminous. So transparent was this tail, the blue sky could be traced through it. The meteor burst, or rather *deployed* (spread itself) and wholly disappeared; *no sparks, no sound.*

"The coastguard on drill at Signal Station, near Brighton, saw the meteor. The body of it appeared like a bottle, half of it a very remarkable deep-red fire; the rest of the body and a tail, a long train of very thin white vapour. When it broke or spread and disappeared, the body, as the sailors call it, assumed a sort of grey hue, which they think was the blue sky seen through the thin white vapour. There was total absence of all noise or sparks; at the moment when immediately over their heads, the "body" (the light part of it) seemed to "quiver," but there was no pause in its course. The "quiver" was, only, if possible, less than an instant."

3. As seen at Ticehurst (near Hurstgreen, Sussex).

Respected and dear Sir,—A meteor of rather remarkable character, I should think, was seen by my schoolboys to pass this morning at $10^h\ 45^m$ A.M. through a clear opening of the clouds, appearing in E. by N. at an altitude of 15°, and disappearing in S.E. at an altitude of 5°. All agree that it appeared half as large as the moon and of a bright yellow colour, very much

more brilliant than the moon when seen in the day. Its flight was not rapid*, and its motion smooth and regular, gliding as a heavy body might be supposed to do. It was attended by a very short train, which rapidly died out and appeared to form a point behind. No noise or explosion was heard. Its path was very slightly curved; but I think there is no dependence to be placed on this. The day was fine, but the sky was partially obscured by large bright floating clouds, high above which was a stratum of a different kind—*cirrus* probably. The sun shone very clearly and warm at intervals, but for a few days previously we have had strong west winds.

I am, &c., R. COVINGTON.

*Ticehurst Schoolhouse, June 20th*, 1866.
*To A. S. Herschel, Esq.*

4. As seen at Boulogne.

To the Editor of the 'Times.'

Sir,—I was at Boulogne this morning at 11 o'clock (Paris time), when an explosion followed by a low and continued rumbling was heard in the Hotel des Bains, where I was then staying. The people in the house ran in alarm from their rooms into the courtyard, asking one another what had happened; then observing through the gateway that similar crowds were also collecting in the street and by the harbour, and were equally puzzled as to the source of the noise, I went out and found myself in ample time to see the long, narrow, smoke-like train of a meteor hanging in the sky. The final puff that indicated the place of explosion was marked with perfect distinctness, but the point where the train first commenced was hidden from my view by a block of houses. I leisurely noted the necessary bearings, and then, running to my room, returned with a small travelling "altazimuth" I had by me, and measured them. The results were:—for the first point in the train that I could see, altitude 62°, magnetic azimuth (E. from N.) 95°; for the final puff, altitude 40°, magnetic azimuth (E. from N.) 195°.

I doubt the error in any of these observations exceeding one degree; I feel sure it does not exceed two degrees. The average breadth of the train of smoke was about one degree. A comparison of these measurements with any set taken elsewhere—and doubtless you will receive some other communications—will at least indicate the path of the meteor, and will accurately fix its height above the earth at the time of explosion.

(Signed) FRANCIS GALTON.

*London, June 20th.*

5. As seen in France. (From the 'Morning Advertiser,' June 26th.)

The meteor described as having shot through the clouds over Folkstone on the 20th June, flamed amazement through all the towns in the northern department of France. It crossed over Boulogne, Calais, Hazebrook, Aire, Lilles, Bombourg and other places, and ultimately burst over St. Omer with an explosion like the roar of artillery. The peaceful inhabitants imagined an explosion of the neighbouring powder-magazines at Esquades. It is known to have exploded between the towns of Boulogne and St. Omer; but, though diligent search has been made, none of the fragments have been discovered.

* One boy, who saw the meteor from first to last, was asked to point with a stick towards the place whence it appeared to him to move. Moving the stick as the meteor appeared to him to do, the time in which he described the whole course of the meteor's flight, up to the point of disappearance, was 3¼ seconds.

6. The explosion at Calais. (Extract from a letter to the 'Times,' from H. B. M. Consul at Calais, Beaumont Hotham.)

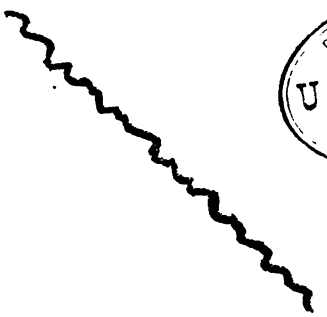
Sir,—The information of the explosion of a powder-mill near St. Omer, though transmitted by telegraph from St. Omer to Calais, and though officials here were informed of the "explosion," and the St. Omer fire-engines were actually sent for, turned out to be incorrect. The meteor was of a very extraordinary description; but the powder-mill, at least, was a *canard*.

(7.) 1866, July 17th, $8^h\ 52^m$ P.M. (local time), Eidfjord, Norway.

It was quite light when the meteor appeared, far too light for any stars to be visible, and yet the meteor was very bright. I have no doubt it would have given very much more light than the moon, yet it was only about one-third the apparent diameter of the moon.

I first saw it at an altitude of perhaps 45°; and after that it went about 50°, increasing in brightness as it went. The latter part of its course was at an angle of 45° downwards to the right. It had a bright tail 5° or 10° long, of a different colour from the head, I think fiery; it vanished with the head; but I very soon saw a white train, perhaps 20° long, somewhat serpentine, exactly like white smoke, doubtless illuminated by daylight alone, as I do not think that it was at all self-luminous. It was consequently very faint to my naked eye. Some of the party saw it before I did, and say that it was simply curved and not serpentine.

It rapidly became more serpentine, and perhaps two minutes after the disappearance of the meteor was of this shape:—



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It continued to grow more serpentine till it disappeared, part of it remaining visible twelve minutes.

I remain, yours truly,

*Sunderland, Sept. 10th*, 1866. T. W. BACKHOUSE.

*To A. S. Herschel, Esq.*

## III. AËROLITES.

(1.) 1860, January 16th. Stonefall at Kusiali, Kumaon, India.

(2.) 1865, January 19th. Stonefall at Mouza Khoona, Sidowra, Gorruckpore district, India.

(3.) 1865, August 12th, $7^h$ P.M. Stonefall at Dundrum, county of Tipperary, Ireland (Scientific Papers from R. I. Academy's Proceedings, vol. i. p. 230).

Meteor not seen. A report like a cannon-shot and buzzing noise was heard, and the stone fell into the ground, where it lay, half buried in the earth, milk-

warm. Weight 4 lbs. 14 ozs.; specific gravity 3·07 to 3·57 in different parts of the stone, which has the form of a three-sided pyramid; the base freshly broken; the faces vitrified, and separated from each other by sharp edges of the crust as distinctly as if ruled with a ruler. Of the earthy portion of the meteorite, that which is soluble in muriatic acid is nearly pure olivine; the insoluble portion is a highly siliceous mineral. The proportions are—

| | | |
|---|---|---|
| Nickel-iron (Chladnite) ..... | 20·60 | (Fe 19·57; Ni 1·03) |
| Protosulphuret of iron (Troilite) .. | 4·05 | |
| Chrome iron ore ..... | 1·50 | |
| Mineral soluble in muriatic acid .. | 33·08 | (FeO 5·89; MgO 14·81) |
| Mineral insoluble in muriatic acid .. | 40·77 | |
| | 100·00 | |

(4.) 1865, August 20th, 1h 30m P.M. Erinpoorah, India.
(Extract from an Agra newspaper.)

I send you the following account of an aërolite, together with a photograph of the same, kindly taken by Dr. Eddomes, of the Erinpoorah Irregular Force. On Sunday, August 20th, 1865, about 1h 30m P.M., a loud report was heard at Erinpoorah, as if a heavy gun had been fired in the cantonment. A child in the line called out "look, look, there is a lota* flying over." At the same time a similar report was heard at Sarowli, twenty-four miles south of Erinpoorah, and a borah then saw what he took for a ball of fire pass over his head. The same loud noise was heard at the same time in Aboo, distant fifty-four miles south of Erinpoorah; and there it was followed by a second report, or, as is more likely, a loud reverberation of the first. Some men were digging a tank at the time near the village of Bheenwall in Marwar, about thirty-eight miles from Aboo, when they were suddenly alarmed by a loud rushing noise and a ball of fire near them, throwing up the earth like a shell. Of course they all bolted, but, finding that nothing further occurred, returned to the spot, where from a hole three or four feet deep they dug out this aërolite: weight 3¼ lbs. The appearance of this stone exactly corresponds with the account given of Aërolites in Brandt's Dictionary of Science.

(5.) 1865, August 25th. Shergotty, India.
(Extract from Calcutta Gazette.)

A stone fell from the heavens accompanied by a very loud report, and buried itself in the earth knee-deep. At the time, the sky was cloudy and the air calm, no rain. The stone has been forwarded by the Government to the Asiatic Society of Bengal.

(6.) 1865, August 25th. 11h 30m A.M. Aumale, Algeria.
(Comptes Rendus, 1866, January 8th, vol. lxii.)

A meteorite fell near the small stream Oued Soufflat, thirty-two miles north of the town of Aumale, an explosion like the roar of artillery first proceeding from a cloud in the air. The stone then fell, penetrating in fallow land 8 inches, and burying itself 12 inches deeper in hard calcareous earth, where it remained too hot to be extricated by the hand. Its figure when dug out was a four-sided pyramid, 14 inches high, truncated at the top; the base 8 inches by 6 inches, the upper face 4 inches square. It weighed about 50 lb. A second of the same size fell at a place about twelve miles N. by

* A round vessel used in India to hold or carry water.

E., in N. latitude 36° 27′, E. longitude 3° 40′, which cut off branches from a shrub, excavated a hole 1 yard wide and 1 foot deep, and afterwards rolled down the mountain-side into a pathway, where it was found. The specific gravity is 3·56; the crust is thin, dull black, and rough. The stones attract the magnet, and contain about 10 per cent., by weight, of metallic iron alloyed with nickel. Sulphuret of iron is also present, with chrome-iron in small octahedral crystals. The meteorites contain soluble salts of soda (carbonate and chloride), and consist in their earthy portions of double silicates of iron and magnesia, partly attackable and partly unattacked by muriatic acid. The greenish-grey spherules, very hard and compact, with crystals of Enstatyte and Peridote, and other minerals scattered through the stone, are described by M. Daubrée as they appeared under the microscope.

(7.) 1866, May 30th, $3^h\ 45^m$ A.M. St. Mesmin, Aube, France. (Comptes Rendus, 1866, June 18th, vol. xlii.)

A reddish meteor, drawing a long train of red fire, as seen from Nangis and Bray-sur-Seine, burst over the "banlieue" of St. Mesmin. Its disappearance was followed, at intervals of about twenty seconds towards the E., and of three, four, or five minutes towards the W.S.W., from which quarter the meteor came, by three cannon-like reports. After a clattering noise and a noise like rolling thunder that gradually died away, an aërolite 1 pound in weight struck the earth with a loud shrieking noise* in a railway-cutting at Haute de la Garenne, two yards from the rails, and penetrated 9 inches into the sloping bank. A second, nearly half a mile from the first, was discovered at Bas-le-Brun, which weighed 5 pounds; and a third, weighing 4 pounds, fell one mile from the other two. An indentation, about half an inch in width with a fresh surface, upon the smallest, is covered with thin thread-like lines of the perfectly fused dull black crust, where an angle of the meteorite is supposed from this circumstance to have been broken off during its flight in the air. The specific gravity is 3·56; and the stones contain 5 or 6 per cent. by weight of metallic iron combined with nickel. Protosulphuret of iron and chrome-iron ore are also present. The earthy portion of the meteorites consists of about 60 per cent. of a mineral which is impure olivine, and about 40 per cent. of highly siliceous mineral unattackable by muriatic acid.

(8.) 1866, June 9th. Shortly before $5^h$ P.M. (local time).

Stonefall; Knyahinya, Nagy Berezna, Hungary. (Vienna Acad. Sitzungsber., July 12th, and October 11th, 1866.)

Two scientific persons, commissioned by the government from Pesth, after inquiry upon the spot into the circumstances of this stonefall, gave their report, of which the following is the substance:—

The stones struck the earth in great numbers on an area 1200 yards in length, in lat. 49° N., long. 22° E. from Greenwich. The meteor was seen at distances varying from thirty to seventy-five miles from the place of fall. At Eperies, fifty-five miles west from Knyahinya, it presented the appearance of a burning birch-rod. The handle, which was directed foremost, was deep red: and the meteor shot over Saros and Zemplin to a point due east, where it burst, scattering its fragments in all directions, and houses shook

* An experiment by which most of the different noises made by meteorites in falling, such as humming, buzzing, shrieking, &c., can be imitated, may be made by projecting fragments of iron of different shapes from a common sling.

with the explosion. At Knyahinya the report was like that of a hundred cannons.

A dense cloud, ten times the apparent width of the sun, marked the path of the fireball, extending itself towards Unghvar, a distance of twenty-five miles S., 5° W. from Knyahinya; and it remained visible for fifteen minutes. Two or three minutes after the report was heard, a rattling sound came from the direction of the streak, and labourers at work in the fields saw stones fall. These, when picked up, were ice-cold, and emitted a strong sulphurous odour, that might be perceived at a distance of a mile round the place of fall. At least sixty stones were found, and the largest buried themselves obliquely at an angle of 30° or 35° to the horizon. Thirty-five fragments of the aërolite were sent by the Commissioners to Pesth.

A perfectly incrusted stone was forwarded to Dr. Haidinger at Vienna, who cites the stonefall of Knyahinya, with that of Stannern, as a proof that aërolites, in their native orbits, occasionally consist of a swarm of separate stones, bound together by their mutual gravitation, while yet revolving in an orbit, like one body round the sun. The stone is marked by depressions upon its surface, like a perfect aërolite, and in its interior parts presents a marbled appearance, like the stones of Parnallee and Assam. The specific gravity is 3·520.

## IV.

### (1.) Meteoric showers of October, 1864, and 1865 compared with previous Meteoric showers.

The exact date of the October shower is not fixed, but varies between the 15th and 26th of October. On the 18th of October 1864, and again on the 20th of October 1865, shower-meteors were observed at Hawkhurst, diverging from a particularly well defined radiant, at $\nu$ Orionis, which preserved its place almost fixed in two successive years. The following is a comparison of the meteors mapped with those of other showers. The Table shows that a large percentage of the meteors mapped in the October shower were far more conformable to a radiant-point than was the case with the meteors in any of the other well-known and previously-examined showers. The initials M. N. refer to the Royal Astronomical Society's 'Monthly Notices.'

| Sign of Radiant, and date of observation. | Approximate position of Radiant. | | Conformable meteors mapped. | Meteors mapped excluded from the mean. | Meteors mapped retained in the mean. | Meteors retained. | | | Reference to the original observations. |
|---|---|---|---|---|---|---|---|---|---|
| | R. A. | N. Decl. | | | | Per cent. of meteors mapped. | Mean deviation. | Greatest deviation. | |
| $K_2$ (1864, Jan. 2nd) ..... | 234° | 51° | 26 | 12 | 14 | 54 | 2·0° | 4·1° | Rep. 1864, p. 3[illegible] |
| $DG_1$ (1864, Apr. 19th and 20th) | 277 | 35 | 16 | 7 | 9 | 56 | 3·4 | 6·0 | Ibid. pp. 40–42. |
| G 1863, Dec. 12th and 13th.. | 105 | 30 | 17 | Nos. 10, 12, 14 | 14 | 82 | 2·5 | 6·0 | M. N. xxv. p. 16[illegible] |
| G 1864, Nov. 28th, Dec. 9th. | 94 | 27 | 23 | Nos. 5, 12, 15 | 20 | 87 | 3·0 | 7·0 | Ibid. p. 165. |
| O 1864, Oct. 18th ..... | 90 | 16 | 19 | Nos. 10, 11, 12 | 16 | 84 | 1·6 | 3·0 | Ibid. p. 37. |
| O 1865, Oct. 20th ..... | 90 | 15 | 14 | Nos. 15, 18, 19 | 11 | 84 | 1·4 | 4·0 | M. N. xxvi. p. 5[illegible] |

The meteors observed at Hawkhurst, from which the mean deviations of the first two places of the list were taken, were figured upon a map; and a list of the selected observations (only) is annexed in the following Tables, of which the particulars have already been given fully, or in part, in the Catalogue of the Report for 1864.

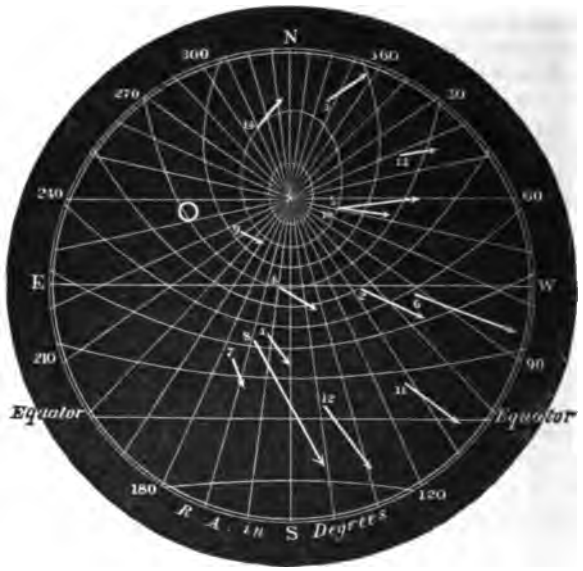
Selected List of Conformable Meteors observed at Hawkhurst, 1864, January 2nd (fig. 1).

| Number. | Hour, G. M. T., 1864, Jan. 2nd. | Magnitude as per stars. | Length of visible path. | Duration of flight. | Apparent path. Began. R. A. | Began. N. Decl. | Ended. R. A. | Ended. N. Decl. | Mean deviation from Radiant. | The meteors are selected from 26 meteors originally entered upon a map. Streak, &c. |
|---|---|---|---|---|---|---|---|---|---|---|
| | h m s | | ° | sec. | ° | ° | ° | ° | ° | |
| 1. | 9 32 0 | 1 | 15 | 1·6 | 162 | 25 | 150 | 15 | 4·1 | |
| 2. | 10 24 45 | 5 | 83 | 1·2 | 106 | 39 | 95 | 20 | 0·5 | |
| 3. | 10 34 0 | 2–3 | 19 | 1·1 | 355 | 67 | 9 | 56 | 2·0 | |
| 4. | 10 40 30 | > 1 | 20 | 1·1 | 158 | 50 | 134 | 39 | 4·1 | |
| 5. | 10 48 15 | 3–5 | 27 | ..... | 66 | 70 | 60 | 47 | 1·7 | |
| 6. | 11 15 15 | 2 | 16 | 1·5 | 92 | 39 | 85 | 13 | 1·1 | Train, 2 seconds. |
| 7. | 11 20 30 | 2–3 | 11 | 1·3 | 176 | 15 | 169 | 7 | 2·4 | |
| 8. | 11 25 30 | 2 | 40 | 2·0 | 167 | 21 | 140 | − 8 | 1·9 | |
| 9. | 11 28 50 | 3 | 8 | 1·0 | 210 | 65 | 191 | 67 | 3·3 | |
| 10. | 11 45 45 | 3 | 15 | 1·3 | 72 | 74 | 66 | 51 | 2·8 | Train, 1 second. |
| 11. | 11 53 30 | 4 | 14 | 1·2 | 111 | 8 | 106 | 0 | 1·8 | |
| 12. | 11 57 0 | 2 | 10 | 1·0 | 137 | 3 | 129 | − 8 | 0·0 | |
| 13. | 11 57 30 | 3 | 12 | 0·7 | 41 | 55 | 42 | 49 | 1·9 | |
| 14. | 12 3 0 | 3 | 18 | ..... | 297 | 70 | 339 | 64 | 0·0 | |
| | Mean values... | ..... | 17 | 1·25 | ..... | ..... | ..... | ..... | 2·0 | |

Selected List of Meteors observed at Hawkhurst, 1864, April 19th and 20th (fig. 2).

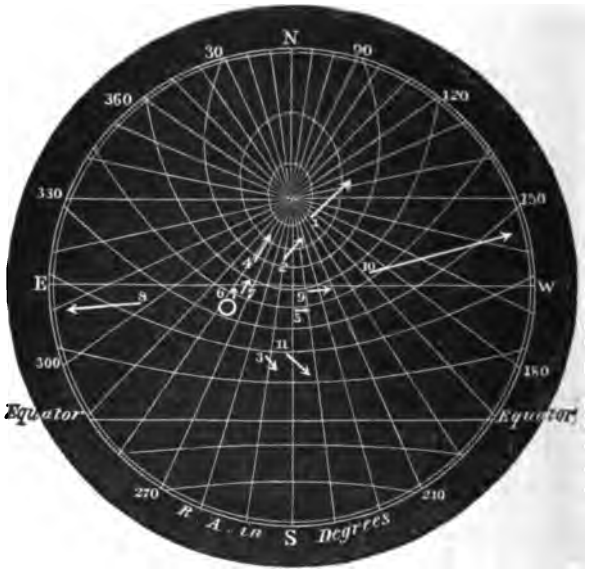
| Number. | Hour, G. M. T., 1864, April. | Magnitude as per stars. | Length of apparent path. | Duration of visible flight. | Position of apparent path. Began. R. A. | Began. N. Decl. | Ended. R. A. | Ended. N. Decl. | Deviation from Radiant. | The meteors are selected from 17 meteors originally entered on a map. Streak, &c. |
|---|---|---|---|---|---|---|---|---|---|---|
| | h m s | | ° | sec. | ° | ° | ° | ° | ° | |
| 1. | 19th. 11 12 0 | 3 | 16 | 0·8 | 181 | 78 | 154 | 69 | 0·0 | |
| 2. | 12 17 0 | 2 | 14 | 0·9 | 253 | 65 | 223 | 75 | 4·0 | |
| 3. | 12 40 0 | 1 | 5 | 0·8 | 252 | 18 | 248 | 14 | 2·3 | Train, 1 second. |
| 4. | 12 53 0 | 1 | 10 | 0·7 | 278 | 62 | 276 | 73 | 1·0 | |
| 5. | 12 59 0 | 2 | 8 | 0·7 | 238 | 39 | 227 | 39 | 4·0 | |
| 6. | 14 25 0 | 2 | 6 | 0·7 | 277 | 39 | 281 | 44 | 2·5 | |
| 7. | 14 29 30 | 2 | 15 | 0·9 | 273 | 41 | 276 | 49 | 5·5 | |
| 8. | 14 55 30 | 3 | 10 | 0·6 | 301 | 23 | 308 | 15 | 6·0 | |
| 9. | 20th. 10 55 0 | 1 | 15 | 1·2 | 230 | 49 | 208 | 46 | 5·8 | Train, 2 seconds. |
| | Mean values... | ..... | 11 | 0·8 | ..... | ..... | ..... | ..... | 3·4 | |

Fig. 1.




Radiant $K_2$; 1864, January 2nd. R. A. 234°, N. Decl. 51°.

Fig. 2.




Radiant D $G_1$; 1864, April 19th to 20th. R. A. 277°, N. Decl. 35°.

(2.) Meteoric shower of 1865, November 13th, A.M.

Mr. W. H. Wood reports at Weston-super-Mare:—On the night of the 12th of November, from $5^h$ to $8^h$ P.M., and again at $11^h$ $30^m$ P.M., the sky was clear at intervals, but no meteors were seen. After midnight the sky continued overcast until the morning. On the night of the 13th, until $1^h$ A.M. on the morning of the 14th, the sky was partially clear, but no meteors were seen. It then clouded over completely until $4^h$ $30^m$ A.M., when personal watching was abandoned, no symptom of a meteoric shower having appeared up to this time. From $5^h$ $30^m$ A.M. until sunrise the sky was clear (communicated), and orange-coloured meteors appeared, falling at the rate of 12 per hour, from a general altitude of 25° in the N. and N.N.W., vertically down.

Mr. H. Holiday reports at Torquay:—On the night of the 12th of November, at $9^h$ P.M., Cassiopeia was visible through a break in the clouds. The sky was afterwards examined at intervals throughout the night, and was found constantly overcast. On the night of the 13th the sky was very cloudy, and watching on this night was abandoned.

Mr. T. Crumplen reports at London:—"This morning [the 13th] the sky became almost cloudless at $1^h$ $15^m$ A.M. There were fewer meteors than one might expect to see; but those I saw were of all magnitudes, varying from Venus at its brightest to fifth-magnitude stars. The radiant in Leo came out very well; I also suspect a radiant near $\alpha$ Tauri."

Mr. George Knott thus describes the meteors on the morning of the 13th of November, at Cuckfield, in Sussex (see Monthly Notices of the Manchester Lit. and Phil. Soc., Phys. and Math. Section, Dec. 7th, 1865):—Two observers watched the southern half of the sky. "Between $12^h$ and $1^h$ A.M. we counted 39 meteors, giving an average of rather more than 0·6 per minute; the next 55 minutes added 61 to the number, giving an average of 1·1 per minute. After half an hour's interval we resumed our watch at $2^h$ $25^m$ A.M., and between that hour and $3^h$ $5^m$ A.M., when we ceased observing, we noted 55 meteors, showing that the average had risen to 1·4 per minute. The observations of the last 40 minutes showed very clearly that the *radiant-point* was in the immediate vicinity of the star $\zeta$ Leonis, or perhaps between that star and $\epsilon$ and $\mu$ of the same constellation—the neighbourhood, in fact, of what the Rev. C. Pritchard happily terms the "*apex of the earth's way*." The paths of a few meteors seemed to suggest a second radiant-point in the neighbourhood of $\beta$ Tauri, but the observed flights were too few to afford satisfactory evidence on the point."

Mr. R. P. Greg reports at Manchester:—"On the night of the 12th, during the hour from $11^h$ to $12^h$ P.M., I saw only two meteors. It then clouded over, but became quite bright again a few minutes before $1^h$ A.M. Between $1^h$ and $2^h$ A.M. I saw a considerable number, of which I mapped some 20 or 30, but had not time to enter all the particulars. The radiant-point was not quite a definite one, some nearer Leo Minor than Leo. Hardly any were visible, except near the radiant-point; say from Ursa Major to Canis Minor. These November meteors were very phosphorescent, in fact nothing else,—even the larger ones. I saw two from Cassiopeia, the regular radiant, as different as possible in appearance. At $2^h$ A.M. it clouded over."

Observations of the same shower, by Mr. T. P. Barkas at Newcastle-upon-Tyne, Mr. S. H. Miller at Wisbeach, and Mr. S. B. Kincaid at Streatham, near London, will be found in the Catalogue of this Report.

On the morning of the 13th of November, the meteoric shower was observed at the Greenwich and Cambridge Observatories, and at Hawkhurst, with a view to determining the heights and velocities of the meteors. The

hourly number of the meteors is stated by Mr. Glaisher and Professor Challis to have exceeded all before recorded at either of those two observatories. More than 250 meteors (279) were recorded at Greenwich, from shortly after midnight until shortly after $5^h$ A.M.

Nearly a thousand meteors are computed to have been visible at Greenwich during the hours from $1^h$ to $5^h$ A.M., appearing in greatest abundance during the hour from $1^h$ to $2^h$ A.M. Nearly two-thirds (172) left luminous trains visible for several seconds after the disappearance of the meteors. Their unusual number, and the appearance of leaving luminous streaks, agree with Olmsted's description of the famous meteors of the 13th of November 1833, and leave no doubt that the meteors were a partial return of the meteoric shower of that year.

The number of meteors of the first class (16) recorded at Hawkhurst during the hour from midnight to 1 o'clock on the morning of the 14th, was nearly equal to the number (17) recorded, under equally favourable circumstances, during the same hour on the morning of the 13th.

The following are the hourly numbers of meteors observed at the three places during the progress of the shower:—

| Hours of Observation, A.M. | | $0^h$ to $1^h$ | $1^h$ to $2^h$ | $2^h$ to $3^h$ | $3^h$ to $4^h$ | $4^h$ to $5^h$ |
|---|---|---|---|---|---|---|
| Total number of meteors observed at | Greenwich, Nov. 13 ... | 23 | 91 | 66 | 48 | 45 |
| | Cambridge, Nov. 13 ... | 41 | 57 | | | |
| | Hawkhurst, Nov. 13 ... | 17 | 21 | 33 | | |
| | Hawkhurst, Nov. 14 ... | 16 | | | | |

The meteors here recorded, with the exception of six meteors observed at Greenwich, were equal to stars of the 3rd magnitude or upwards. More than half the total number of the meteors were equal to or brighter than 1st-magnitude stars. The number of observers was six at the Greenwich Observatory, three at Cambridge, and one at Hawkhurst. The sky was for the most part cloudless throughout the time, and the moon rose at about $4^h$ A.M.

Amongst the list of shooting-stars seen at Hawkhurst, seventeen were identical with meteors observed at Greenwich. Fifteen other meteors of the list were identical with meteors seen at the Observatory at Cambridge. The heights and velocities of ten of these accordant meteors were calculated (Tables I., II.); and this is also the number of accordances calculated by Drs. Heis and Behrmann, of meteors observed on the same night between Münster and Göttingen. The average height of the middle of the apparent paths differs little, at both places, from sixty miles above the surface of the earth.

Tables I. and II. contain the apparent and computed paths observed at Hawkhurst, Greenwich, and Cambridge. Table III. contains the paths of 10 meteors similarly observed by Dr. Heis and Dr. Behrmann, on the night of the 13th of November, and computed by Dr. Behrmann (Astr. Nachr. vol. lxvi. p. 331–332).

The average velocity of 11 meteors directed from Leo is $55\frac{1}{2}$ English miles per second. The average velocity of 4 meteors directed from Taurus or Perseus is nineteen miles per second. As the former radiant-region is hardly

| Date and hour, 1865, Nov. 13th, Greenwich time, A.M. | Observed at Hawkhurst. | | | | | | Observed at (C) Cambridge, (G) Greenwich. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Magnitude as per stars. | Began. | | Ended. | | Duration of streak. | Initial of station. | Magnitude as per stars. | Adopted points on observed apparent path. | | | | Duration of streak. |
| | | | | | | | | | Began. | | Ended. | | |
| | | Azimuth, W. from S. | Altitude. | Azimuth, W. from S. | Altitude. | | | | Azimuth, W. from S. | Altitude. | Azimuth, W. from S. | Altitude. | |
| h m s | | ° | ° | ° | ° | secs. | | | ° | ° | ° | ° | |
| 0 11 32 | 1 | 220·2 | 48·2 | 174·5 | 55·0 | 3 | C. | 2 | 296·0 | 48·0 | 342·4 | 49·2 | with |
| 0 46 2 | 1 | 222·2 | 50·2 | 180·3 | 57·0 | 2·5 | C. | 1 | 302·4 | 46·4 | 338·8 | 48·3 | with |
| 1 8 37 | 2 | 126·5 | 49·5 | 139·5 | 35·0 | none | C. | 1 | 31·4 | 50·7 | 34·4 | 46·9 | none |
| 1 24 56 | 2 | 213·5 | 29·3 | 197·3 | 24·8 | 2 | C. | 1 | 244·3 | 37·4 | 236·1 | 41·1 | with |
| 1 27 38+ | 1 | 107·0 | 55·3 | 101·8 | 38·5 | 5 | C. | 1 | 44·6 | 54·2 | 55·9 | 38·9 | very fine |
| 1 30 54 | 3 | 37·3 | 58·3 | 53·8 | 46·3 | 1 | G. | 1 | 343·3 | 45·2 | 352·2 | 38·1 | 3 secs. |
| 2 3 38 | 1 | 135·2 | 28·4 | 125·3 | 21·8 | 3 | G. | 1 | 130·3 | 50·7 | 116·8 | 15·3 | very fine |
| 2 4 48 | 2 | 43·8 | 82·8 | 305·6 | 80·5 | none | G. | 1 | 339·4 | 57·3 | 314·7 | 38·9 | 1 sec. |
| 2 9 27 | 1 | 323·0 | 38·7 | 342·0 | 33·1 | 3 | G. | Sirius | 323·0 | 38·7 | 344·7 | 21·0 | 2 secs. |
| 2 37 10 | 2 | 306·3 | 28·8 | 314·3 | 25·3 | 2 | G. | 1 | 287·3 | 29·3 | 308·8 | 17·5 | with |

TABLE II.—Computed Heights, Velocities, &c.

| Beginning. | | | End. | | | Height of centre of path in B. S. miles. | Length of path in B. S. miles. | Duration at Hawkhurst. | Velocity in B. S. miles per sec. | Region of Radiant-point. |
|---|---|---|---|---|---|---|---|---|---|---|
| N. Lat. | Long. from Greenwich. | Height in B. S. miles. | N. Lat. | Long. from Greenwich. | Height in B. S. miles. | | | | | |
| ° | ° | | ° | ° | | | | sec. | | |
| 51·7 | 1·5 E. | 75·5 | 51·6 | 0·4 E. | 53·7 | 64·6 | 53·9 | 1·3 | 40·9 | Leo |
| 51·6 | 1·5 E. | 72·3 | 51·5 | 0·5 E. | 55·1 | 63·7 | 44·7 | 1·5 | 29·8 | Leo |
| 51·5 | 0·6 W. | 67·7 | 51·7 | 0·5 W. | 44·0 | 55·8 | 27·9 | 1·2 | 23·2 | Taurus or Perseus |
| 52·9 | 2·6 E. | 88·6 | 52·7 | 1·4 E. | 56·9 | 72·8 | 61·0 | 0·8 | 76·2 | Leo |
| 51·4 | 1·3 W. | 114·5 | 51·4 | 2·0 W. | 86·1 | 100·3 | 41·6 | 1·0 | 41·6 | Leo |
| 50·7 | 0·1 E. | 49·3 | 50·7 | 0·1 W. | 35·2 | 42·2 | 17·2 | 0·7 | 24·5 | Leo |
| 51·9 | 0·8 W. | 43·3 | 52·4 | 2·8 W. | 68·5 | 55·9 | 96·1 | 1·0 | 96·1 | Leo |
| 51·9 | 0·4 E. | 56·7 | 52·0 | 0·6 E. | 47·4 | 52·1 | 14·7 | 0·8 | 18·4 | Perseus |
| 48·9 | 2·9 E. | 146·9 | 49·6 | 1·2 E. | 68·1 | 107·5 | 120·6 | 0·9 | 134·0 | Leo |
| 50·6 | 1·3 E. | 24·8 | 50·6 | 1·2 E. | 19·9 | 22·3 | 8·4 | 0·7 | 12·0 | Leo |
| Mean heights ... | | 74·0 | ..... | ..... | 53·5 | 63·7 | | | | |

TABLE III.—Heights &c. of November Meteors observed at Göttingen and Münster.

| No. | Date, 1866, Nov. | Hour, Göttingen mean time, P.M. | Magnitude as per stars, &c. | Streak, if any, left. | Height in B. S. miles. | | Height of centre of path in B. S. miles. | Length of path in B. S. miles. | Velocity in B. S. miles per sec. | Region of Radiant-point. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | At beginning. | At end. | | | | |
| | | h m s | | | | | | | | |
| 1. | 13th | 8 30 12 | 1–2 | ..... | 59·8 | 51·0 | 55·4 | 48·9 | 44·5 | Cassiopeia |
| 2. | " | 10 24 3 | 1–2 | ..... | 89·5 | 252·1 | 170·8 | 254·6 | 53·0 | Leo |
| 3. | " | 10 28 15 | 1–3 | ..... | 46·9 | 38·1 | 42·5 | 12·2 | 17·4 | Perseus |
| 4. | " | 10 32 44 | 1 | with | 80·9 | 31·2 | 56·1 | 159·6 | 55·1 | |
| 5. | " | 10 41 55 | 3–5 | ..... | 72·4 | 50·1 | 61·3 | | | |
| 6. | " | 10 58 39 | 4–1 | with | 86·4 | 47·6 | 67·0 | 198·0 | 66·0 | Leo |
| 7. | " | 11 0 20 | ♀–1 | with | 90·0 | 44·6 | 67·3 | 73·2 | 36·6 | Leo |
| 8. | " | 11 12 2 | ♀–1 | with | 80·3 | 44·2 | 62·3 | 33·0 | 16·5 | Perseus |
| 9. | " | ..... | 1–2 | with | 73·2 | 62·2 | 67·7 | | | |
| 10. | 14th | ..... | ..... | ..... | 94·3 | 32·9 | 63·6 | | | |
| Mean heights ..... | | | ..... | ..... | 76·0 | 44·6 | 60·3 | Omiting heights of No. 2. | | |

20°, and the latter more than 100° removed from the "*apex of the earth's way*," it follows that the earth's motion of translation is plainly recognized as the result of observation, by its effect of increasing the speed of the meteors from the former radiant-point to 55½ miles per second, and diminishing the speed of the meteors from the latter radiant-point to nineteen miles per second.

The position of the radiant-point in some part of the constellation Leo was noted, with the following results, at Greenwich and at Hawkhurst—to which are added the positions of the same radiant-point observed by Dr. Heis, and by observers in America, on the morning of the 13th of November 1865:—

| Place and Observer's name, and Hour of Observation. | Position of Radiant in Leo, 1865, Nov. 13th, A.M. |
|---|---|
| Greenwich ..... ($1^h$ to $5^h$ A.M., Mr. Glaisher) .. | R. A. 160°, N. Decl. 30° |
| Hawkhurst..... ($1^h$ to $3^h$ A.M., Mr. Herschel) .. | „ 148 „ 23 |
| Münster ..... ($0^h$ to $0^h$ $30^m$ A.M., Dr. Heis) .. | „ 148 „ 24 |
| Newhaven, U. S... (Prof. H. A. Newton)..... | „ 148 „ 23 |
| Philadelphia, U. S. (Mr. B. V. Marsh) ..... | „ 148 „ 24 |

The four latter positions are in remarkably close agreement with the position of the same radiant-point (R. A. 148° 10′, N. Decl. 23° 45′) observed by Professor Aiken at Emmettsburg, Md., U.S.A., from $4^h$ $45^m$, to $6^h$ $45^m$ A.M., on the 13th of November 1833. (Am. Journ. Sci., 1st Series, vol. xxvi. p. 330.)

(3.) Meteoric Shower of January 2nd and April 20th, 1866.

The January and April showers, in 1866, as shown by observations contained in the Catalogue, were completely in default.

(4.) Meteoric Shower of May 18th, 1866.

Meteors of the first class (7=1st-mag., 2=2nd-mag., 3=3rd-mag. stars) were observed at the Royal Observatory, Greenwich, towards midnight on the 18th of May 1866, falling at the rate of 12 per hour. The radiant-point, although somewhat indefinite, was distinctly the radiant $Q_2$ (No. XX*a*) of Dr. Heis and Mr. Greg, between Corona and the Head of Hercules. The date, on account of the possibility of a connexion existing between shower meteors in May and the star-showers of November, merits attention, with the view of determining further points of radiation.

(5.) Meteoric Shower of August 1866.

A period of about 103 years, noticeable in the returns of the August meteors, would bring two star-showers of the years 830 and 833 A.D., cited by Biot from the Chinese Annals, into immediate relation with the phenomenon of the 10th of August, 1863, to which the first or second of these star-showers might correspond.

The hourly number of meteors on the night of the 10th of August, 1866, was not greatly above the ordinary scale of the phenomenon. A large meteor appeared in daylight over the south of England at $8^h$ $15^m$ P.M., on the evening of the 8th; and a large fireball was observed at Hawkhurst at $0^h$ $42^m$, on the morning of the 10th.

At the Royal Observatory, Greenwich, the sky was clear on the 7th, and 175 meteors were observed. Two meteors were observed through a break in the clouds on the 8th. The sky was again clear on the 9th, and 113 meteors were mapped in a few hours. On the night of the 10th, 24 meteors were observed through breaks in the clouds. The radiant was in Perseus.

At Richmond, near London, on the night of the 10th of August, the clouds

began to break at midnight; and the sky was completely clear at $0^h\ 15^m$ A.M. on the 11th. Between the hours of $11^h\ 55^m$ P.M. on the 10th, and $1^h\ 5^m$ A.M. on the 11th, Mr. J. Browning counted 26 meteors—six first-class, leaving trains (3 blue, 2 yellow, 1 white). A third part of the sky was in view throughout the time.

At London, Mr. T. Crumplen reports meteors very scanty on the 9th. There was a thunderstorm on the 10th, with cloudy and unsettled weather until $11^h$ P.M. The sky was afterwards clear at intervals. Electrical-looking clouds and distant lightning were conspicuous through the night as in previous years. A few meteors were observed radiating from B Camelopardi and a Lyræ.

At Birmingham, Mr. W. H. Wood reports:—"The present return of the August meteors has exceeded the ordinary scale of the phenomenon in point of numbers, and exhibits a radical and probably a physical difference in the nature of the substance composing the meteoric shower, as compared with that of August 1864. In the latter, various tints of yellow and red were its characteristics, whilst the present shower is almost entirely composed of *blue* meteors of the *smaller class*, the proportion of colours being as follows—

| Red. | Orange or yellow. | White. | Blue. | Total. |
|---|---|---|---|---|
| 5 | 11 | 12 | 42 | 70 meteors; |

and the proportion of magnitudes being—

| =Jupiter. | =Sirius. | =1st mag. | =2nd mag. | =3rd mag. |
|---|---|---|---|---|
| 1 | 9 | 14 | 22 | 34 |

Total, 80 meteors.

"One-fourth part of the meteors left phosphorescent trains.

"The prolongation of the meteors' paths towards the points of origin, indicated two areas of radiation whence the entire shower emanated—one radiant area about δ Persei, and the other about D Camelopardi.

"The rate of appearance recorded by an unassisted observer was as follows:—

| | Aug. 8th, $10^h$ to $11^h$ P.M. | 9th, P.M. | 10th, P.M. | 10th, $11^h$ P.M. to 11th, $1^h$ A.M. |
|---|---|---|---|---|
| Meteors per hour | 12 | 12 | 16 | 20 |

and these numbers are probably less than half the real ratio."

At Hawkhurst, on the nights of the 9th and 10th, the sky was remarkably clear to unaided vision. Bright meteors were frequent, and a large fireball burst overhead on the morning of the 10th. The meteor itself was not seen; but a streak was left for 20 seconds, and the flash of light resembled that of lightning; no report was heard. The hourly number of meteors for an unassisted observer was about 15 per hour on the 9th, increasing to very nearly 30 per hour on the morning of the 11th. On the night of the 11th the sky was overcast.

### Observations of August Meteors, 1866, with the Spectroscope.

Mr. Browning having constructed three binocular spectroscopes for the British Association, on a plan approved by the Committee, for examining the spectra of meteors in the next November shower, the instruments were employed by Mr. Glaisher, Mr. Herschel, and Mr. Browning, to examine the spectra of meteors on the 9th and 10th of August. Owing, however, to a delay in the delivery of the instrument at Greenwich, observations of meteor-spectra could not be commenced until the 10th. At the Royal Observatory, Greenwich, and at Richmond on Thames (Mr. Browning's station), the sky

on the night of the 10th was for the most part cloudy, and all attempts to catch the spectrum of a meteor proved in vain.

Spectrum observations were begun at Hawkhurst on the evening of the 9th; and the sky proving remarkably clear for this kind of observations, they were continued, until daybreak, on the following nights of the 9th and 10th.

No difficulty was found in mapping the course of the meteors in the spectroscope by the stars, of which a whole constellation, as for example the seven stars of Ursa Major, are seen in the instrument at once. The brightness, duration, and length of path, and whether the meteor left a streak upon its course, could also be noted in the instrument as readily as with the unassisted eye; so that by this means the apparent paths of 17 meteors were noted in six hours, of which all, or all but one, diverged from Perseus and Cassiopeia. The proportions of magnitudes were as follows:—

| =Sirius. | =1st mag. | =2nd mag. | =3rd mag. | =4th mag. |
|---|---|---|---|---|
| 2 | 4 | 4 | 4 | 2 |

The spectroscope being so held that the course of the meteors was parallel to the refracting edges of the prisms, the appearance of their meteoric spectra was found to be, in general, altogether different from the view of the same meteors obtained by the naked eye. Nevertheless in one instance (No. 8) the appearance of a meteor in the spectroscope was unaltered, being that of an ordinary bright shooting-star, leaving a slender yellow streak upon its course. In some cases (of the most conspicuous streaks), the appearance of the brightest and last fading portion of the streaks in the spectroscope was the same as to the naked eye, being a bright-yellow-coloured, slender line. Lastly, when the spectrum of the meteoric streak was diffuse, a bright-yellow very slender line was frequently observed in the spectrum on the side towards the red, which either faded away simultaneously with the diffuse portion of the spectrum, or, more commonly, remained visible alone after that portion of the spectrum had disappeared. The bright-yellow line was observed in eight cases among 17 meteoric spectra. Its presence in a very conspicuous form in many of the streaks leads Mr. Herschel to the conclusion that the metal sodium is abundant in the 10th of August meteors. The following account of the original discovery of a yellow line strongly resembling that of sodium in the train-spectra of the August meteors, is taken from Mr. Herschel's description of the observations, in the 'Intellectual Observer' for October, 1866, where it is accompanied by a tinted plate:—

"All the necessary preparations having been made, and with the prospect of a considerable meteoric shower at hand, a watch for meteors was commenced, in order to observe their spectra, on the night of the 9–10th of August last. Expectation on the first night was not destined to be disappointed, and six meteors were observed to pass across the field of view. Notes of the peculiarities were made, and of the general appearance of their spectra, and are briefly as follows:—

"*August 9th.*—No. 1, $8^h\ 40^m$ P.M. About equal to a fourth-mag. star. Passed across the body of Cygnus in half a second, leaving no streak. The spectrum exactly resembled that of a fourth-mag. star ($o$ Cygni), close to which the meteor passed, the conclusion being that *the meteor might be a solid body heated to ignition.*

"*August 10th.*—No. 2, $0^h\ 27^m$ A.M. Nearly as bright as Sirius. Commenced near Polaris (in the field of view), and shot 15° or 20° (beyond the field of view) along a line directed from Cassiopeia, leaving a streak on its whole course for four seconds. The latter part of the meteor's course was

seen with the naked eye. In the spectroscope, two images of the meteor and of the streak were visible, one refracted, and one accidentally reflected at the side. These two images of the meteor and of its streak could not be distinguished apart, at least in their general appearance,—the conclusion being that the light, both of the nucleus and of its luminous streak, was homogeneous, and that *its luminous substance was a gas.*

"No. 3, $0^h$ $42^m$ A.M. A very brilliant fireball with a flash like lightning burst overhead, leaving a streak from $\theta$ Cygni, halfway to $\alpha$ Lyra, for twenty seconds. A cloud unfortunately dimmed the streak. In the spectroscope, as far as cloud would permit any judgment of the streak to be formed, its aspect was the same as to the unassisted eye. The light of the streak was therefore probably homogeneous, and *the streak itself probably a luminous gas.*

"No. 4, $1^h$ $15^m$ A.M. About equal to a second-mag. star. Shot in three-quarters of a second from $\theta$ Cassiopeiæ, halfway to $o$ Honorum, and then turned round the quarter of a circle to $u$ Honorum, where it vanished, leaving a streak for half a second on its course. In the spectroscope, the general appearance of the meteor and of the streak in the field of view was the same as that of the purely reflected image by the side,—the conclusion being, as before, that the light, both of the meteor and of the streak, was homogeneous, or that *the luminous substance of the meteor was a gas.*

"No. 5, $1^h$ $40^m$ A.M. About equal to a second-mag. star. Passed slowly through a short path near $\beta$ Tauri, directed from Cassiopeia; duration one second, leaving a streak at the place for three seconds. The spectrum of the meteor and streak was quite equally diffused over a space about $\frac{1}{4}°$ in width; its colour greyish white; the diffuse train-spectrum vanished without further change,—the conclusion being that in this case *the train might, like the nucleus, be composed of heated sparks.*

"No. 6, $2^h$ $15^m$ A.M. Equal to a first-mag. star. Shot on the same course as No. 2; duration one second, leaving a bright streak for four seconds. The spectroscope was turned towards the streak before it disappeared. The train was widened by the prisms to a greyish-white band, somewhat greater than a quarter of a degree in breadth. It faded from sight without further change,—the conclusion in this case also being that *the train might possibly be composed of heated sparks.*

"Three spectra in the foregoing observations appeared homogeneous, like that of a luminous gas (Nos. 2, 3, 4); and three were continuous or diffuse (Nos. 1, 5, 6), like that of an ordinary spark. The question, accordingly, whether luminous meteors might or might not contain solid substance, remained undecided, when daylight beginning to appear put a stop to further observations.

"The following night observations could fortunately be resumed; and the perplexing appearance of the meteor-spectra on the previous night received a truly surprising and most satisfactory explanation, in the repeated appearance in the spectra of the streaks of a yellow line, *unmistakeably that of the metal sodium in combustion.*

"Two observers being engaged to watch on this night, one checked the observations of the other with the naked eye. The troublesome reflected image in the spectroscope could accordingly be dispensed with, and it was kept out of sight; so that the views obtained of the meteor-spectra came as nearly to perfection as could be wished.

"*August 10th, continued.*—No. 7, $4^h$ $22^m$ P.M. Equal to a first-mag. star. Shot from $\gamma$ Cephei to $l$ Draconis in three-quarters of a second, leaving a bright streak for five seconds on its course. The meteor first appeared in the

field of view, and passed out of it. The brightest portion of the streak, however, was brought into the middle of the field of view, where it occupied an excellent position (parallel to the refracting edges of the prisms) for viewing its prismatic spectrum. A slight effect of distortion (produced in the prisms) caused it to appear somewhat bent, like a bow, across the field of view. The spectrum presented the appearance of a narrow line of light, exceedingly brilliant, of a golden-yellow colour, and not more than 5′ in width. It faded gradually along its whole length, and disappeared in about two and a half or three seconds. Its description, noted in the register, kept for the purpose at the time, was—"neither double, triple, nor multiple, nor continuous, *but purely and positively monochromatic.*"

"*August* 11*th*.—No. 8, $0^h\ 15^m$ A.M. Equal to a third-mag. star. Shot from $\beta$ Cephei to $\delta$ Draconis in three-quarters of a second, leaving a luminous streak for two seconds. The spectrum of the streak was a remarkably slender orange-yellow line of no appreciable breadth, without any continuous spectrum near to it, or any other neighbouring bands or lines. It was very bright, remaining in sight two seconds, and it gradually faded away until it vanished. The spectrum of the nucleus appeared to be undistinguishably the same as that of the streak.

"No. 9, $0^h\ 20^m$ A.M. Equal to a third-mag. star. Shot from $\alpha$ Cephei to 33 Cygni (Fl.) in three-quarters of a second, leaving a streak for one second and a half. The spectrum of the streak was dull grey, diffuse, about $\frac{1}{4}^c$ in width, with a yellow line included in it *on the side towards the red.* The yellow line and the diffuse band disappeared together. The spectrum of the nucleus appeared to be appreciably the same as that of the streak.

"No. 10, $0^h\ 33^m$ A.M. Equal to a fourth-mag. star. Shot from $\rho$ Cassiopeiæ to $o$ Honorum in half a second, leaving no streak. The spectrum of the nucleus appeared to be concentrated into a few faint lines with wide intervals between them; but this description is very uncertain.

"No. 11, $0^h\ 33^m$ A.M. Equal to a third-mag. star. Returned about halfway along the course of the preceding meteor in half a second, leaving no streak. The spectrum of the nucleus was a concentrated point of yellow light, having all the appearance of an ordinary yellow shooting-star.

"No. 12, $0^h\ 42^m$ A.M. Equal to Sirius; colour white. Shot from $\alpha$ Trianguli to $\eta$ Piscium in one second and a quarter, leaving a streak for four seconds on its course. In the spectroscope the meteor slowly crossed the middle of the field of view, on a course directly parallel to the refracting edges of the prisms, producing a very superb spectrum. The spectrum of the nucleus was red, green, and blue, extremely brilliant. The train-spectrum was diffuse, $\frac{1}{4}^\circ$ in width, in which a thin bright orange-yellow line was plainly seen *on the side towards the red.* The diffuse portion of the train-spectrum faded in about two seconds, apparently following the nucleus. The sodium line remained extremely bright for not less than two seconds longer, and faded gradually along its whole length, when it also disappeared. The singular characters of this spectrum were most distinctly and beautifully seen, and the long endurance of the sodium line, after the rest had disappeared, was leisurely watched.

"No. 13, $1^h\ 23^m$ A.M. Equal to a third-mag. star. Shot from P Camelopardi to $\alpha$ Draconis in half a second, leaving a streak for two seconds on its course. The train-spectrum was a diffuse band of greyish light $\frac{1}{4}^\circ$ wide, somewhat brighter on the side towards the red, and it so vanished. The spectrum of the nucleus was appreciably the same as that of the streak.

"No. 14, $1^h\ 55^m$ A.M. Equal to a first mag. star. Shot from $o$ Custodis to

3° below Polaris in three-quarters of a second, leaving a bright streak for three seconds. The meteor first appeared in the field of view, and passed out of it. The spectrum of the early portion of the streak, behind the nucleus, was a greyish diffuse band ¼° in width. The spectrum of the nucleus was appreciably the same. The brightest part of the streak, before it faded, was brought into the field of view, well situated parallel to the edges of the prisms, and in the middle of the field for about two seconds. Its appearance was that of a golden-yellow line of light about 5° in length, some 4′ in width, tapering gently towards the ends, and perfectly sharp and well defined. It was unaccompanied by any continuous spectrum, or any bands or other lines, and it so disappeared from the ends towards the centre.

"No. 15, $2^h\ 15^m$ A.M. Equal to a second-mag. star. Shot from $\mu$ to $\alpha$ Andromedæ in three-quarters of a second, leaving a streak for two seconds. The train-spectrum was a diffuse greyish-white band, ¼° in width, and about 6° or 7° long, and faded away without any further change. The spectrum of the nucleus showed prismatic colours.

"No. 16, $2^h\ 16^m$ A.M. Equal to a second-mag. star. Shot from $\delta$ Cassiopeiæ to $\beta$ Andromedæ in half a second, leaving a streak for two seconds and a half. The meteor was seen with the unassisted eye. The last-fading portion of the streak was examined in the spectroscope, where it appeared more widely diffused than when seen with the naked eye. Its colour in the spectroscope was a dull greyish white.

"No. 17, $2^h\ 27^m$ A.M. Brighter than a first-mag. star. Shot from $\alpha$ Cassiopeiæ to $o$ Honorum, leaving a streak for two seconds and a half. The train-spectrum was a diffuse greyish-white band ¼° in width, not sensibly brighter in any part, and it so faded. The spectrum of the nucleus was bright red and green.

"Daylight at this time began to appear, and observations were obliged to be discontinued; the streaks of the August meteors might, however, already be plainly divided into two classes. In the majority of cases, a bright yellow line, having the unmistakeable appearance of the sodium line, was clearly visible in the spectrum. In a smaller number of cases the spectrum was merely a diffuse and greyish light band, or ordinary spectrum of weak intensity, resembling the spectrum of the glowworm's light. It will be interesting to observe this form of meteoric spectrum, should it be more common among the "phosphorescent" streaks of the November meteors than it was in August last, when only five such purely "phosphorescent" streaks were noticed entirely free from sodium light.

"The spectra of the meteor-nuclei were seen in a few cases only with distinctness, as they were in general overpowered by the brightness of the sodium light whenever that was present. When the streaks were phosphorescent only, and free from sodium light, the nuclei in general presented highly-coloured spectra, like the spectrum of solid matter at a glowing white heat, or like the spectrum of an ordinary gas-flame containing white-hot solid particles of carbon. A better night for observing nucleus-spectra would be the 12th of December, when meteors leaving no trains are plentiful; and they are for the most part very brilliant, radiating from some part of the constellation Gemini.

"That which spectral examination of the August meteors has most certainly brought to light is the existence of an extraordinary quantity of the vapour of sodium in their luminous streaks; so that many of the streaks, especially the most conspicuous and the most slowly-fading amongst them, consist of nothing else but soda-flames for a great proportion (that is to say, the latter

portion) of the time that they continue visible. Their condition is then exactly that of a flame of gas in a Bunsen's burner, freely charged with the vapour of burning sodium, or of the flame of a spirit-lamp newly trimmed and largely dosed with a supply of moistened salt.

"It is difficult to believe that the vapour of the metal sodium exists in such considerable quantities at the confines of the atmosphere. It is much more reasonable to suppose that it is brought into the atmosphere by the meteors themselves, so as to be deposited in the luminous trains that mark their course. The material of the August meteors is, therefore, probably a mineral substance in which sodium is one of the chemical ingredients. Such is the rather satisfactory termination of an experiment which it will be very easy to repeat whenever an abundance of meteors on the night of the 10th of August offers an equally favourable opportunity for examining their spectra by the aid of the meteor spectroscope.

"The connexion believed by adherents of Chladni to exist between shooting-stars and aërolites is now shown, at least in August, to extend itself in some measure to their chemical composition. The meteorites of Aumale, which fell on the 25th of August 1865, were found, on analysis by M. Daubrée, to contain *soluble salts* (chloride and carbonate) of sodium. A circumstance so uncommon in the composition of aërolites, allies the meteorites of Aumale very closely with the sodium-bearing streaks of the meteors of the 10th of August.

"In this manner, each new acquisition of knowledge, however unforeseen may be its origin, tends to support the theory of Chladni, and to confirm the belief that shower-meteors and shooting-stars are actually aërolites of small dimensions. In whatever manner aërolites and shooting-stars are related to each other in their astronomical and other peculiarities, they will evidently require a vast number of further experiments to unfold their real source."

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## *Report of the Committee appointed to Investigate the Alum Bay Leaf-Bed. By* W. Stephen Mitchell, *LL.B., F.G.S., Caius College, Cambridge.*

The bed known to geologists as the "Leaf-bed," or "Pipe-clay bed," of Alum Bay, is the band of white clay which occurs in the lower Bagshot beds in Alum Bay, about 200 feet from their base (No. 42 in Memoir of the Geological Survey). It is about 6 feet thick; but one portion only, a few inches in thickness, contains the plant-remains. No other organic remains whatever have been noticed.

The occurrence of these plant-remains was first observed by Mr. Prestwich (see Geol. Soc. Journ. 1847, p. 395), and since then collections have been made.

Dr. P. de la Harpe, of Lausanne, examined these, and gave a notice of several species in a paper on the "Flore tertiaire de l'Angleterre," which appeared in the 'Bulletin de la Société Vaudoise des Sciences Naturelles' for June 1856. In December 1860, in conjunction with Mr. J. W. Salter, F.G.S., he prepared the list which is published in the memoir of the Geological Survey of the Isle of Wight.

This list includes the collections from "the same strata worked at Bournemouth and Corfe Castle, in Purbeck, Dorset;" yet for the compilation of it

the total number of specimens that could then be brought together from the three localities was but about 300.

It is therefore no matter of surprise that in larger collections since made many fresh forms are met with.

At our last Meeting at Birmingham I exhibited drawings of some few of the most striking new forms, and mentioned that both Dr. P. de la Harpe and Dr. Oswald Heer urged the importance of a more careful examination of this flora.

A committee for this purpose was appointed, and the sum of £20 was placed at our disposal. Through the kindness of Professor Sedgwick and the Vice-Chancellor of the University of Cambridge, we obtained the services of Mr. H. Keeping, now at the Woodwardian Museum, who has had much experience in the working of this bed.

I went down to Alum Bay last September with Mr. Keeping, and remained there during the working to note the appearance of the leaves when first turned up.

In the majority of instances, not only the outline, but the venation, even the most delicate, is at first clearly visible, though a few hours' exposure to the air almost obliterates the more delicate marks. A washing with a solution of isinglass often preserves them; indeed in some instances it brings them out even more sharply; but, unfortunately, it often fails. There are some specimens on which I partly traced the venation with pencil as soon as they were exposed; now, after an interval of ten months, they are so faded that the part not pencilled is hardly, if at all, to be made out. It is much to be regretted that there is this difficulty in preserving the specimens, and we shall be very glad to receive suggestions for their treatment. All our specimens have had the usual isinglass wash, though I fancy it somewhat obscures the character of the *surface* of the leaves. I cannot speak with certainty on this point; for, as I had not anticipated such a result, I did not record the character of the surfaces among the notes I made on the spot. Still, from comparing the recollection I have of the appearance of the leaves when first turned up with their appearance now, I am almost certain this is the case. This I the more regret as the character of the surface of a leaf is often a useful help in determining its genus. I hope to have an opportunity of again examining this bed; and I shall endeavour to take both drawings and complete descriptions of the leaves before the air and light have in any way injured them.

After a fortnight, bad weather put a stop to our work. We had, however, succeeded in obtaining a good collection, numbering altogether some 470 specimens. The leaves are, on the whole, well preserved, but the bed in one part yielded forms so indistinctly marked as to be almost worthless.

I have in course of preparation descriptions of all the leaves in this, as well as in my own collection, which I will lay before one of the learned societies of London*.

Were they now complete, this would not be the suitable place for reading them; and the publication of them in a report, without drawings, would much lessen their value.

I have brought drawings of some of the leaves, which show that the aid afforded by this Association for examining this bed has helped us to obtain, not only finer specimens than Dr. P. de la Harpe and Mr. Salter had at their disposal, but also many fresh forms.

* The Palæontographical Society has undertaken the publication of a monograph.

I decline to attempt to fix the number of new species, or even genera, which we are able to add to the list in the Survey Memoir; for not only is the determination of fossil leaves at all times very unsatisfactory, but that list was not intended for a monograph, and has neither drawings (except a few) nor the exactness of description requisite for identification. Then, too, the nomenclature of fossil leaves is very unsettled, the same leaf having often half a dozen different names.

With regard to the species of fossil leaves, I believe the word "form" might often with advantage be used where "species" is now universally employed. "Species" is applicable only to the entire plant; "form" is applicable to individual leaves. When we consider the variation often met with in leaves growing on the same tree, I think we see reason for great caution in determining what "forms" represent the existence of distinct "species."

[Mr. Mitchell exhibited photographs and drawings of some of the larger and more interesting leaves].

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*Report of the Committee appointed to make Experiments on the difference between the Resistance of Water to Floating and to Immersed Bodies. The Committee consists of* JOHN SCOTT RUSSELL, *C.E., F.R.S.*; JAMES R. NAPIER; Professor RANKINE, *C.E., F.R.S.*; *and* W. FROUDE.

THE following Report describes the experiments made by the Committee.

The Committee held several meetings in the course of the winter and spring of 1864–65, and agreed to a programme of experiments, of which the following is a summary:—

"1. Two models to be made of painted wood, designated respectively as A and B.

"2. The models to be ship-shape, and each of them to consist of two equal and similar halves joined together at the middle water-line.

*Elements of Models.*

| | A. | B. |
|---|---|---|
| Length | 4 feet | 4 feet |
| Breadth, ¼ of length | 0·571 foot | 0·571 foot |
| Total depth | 0·571 foot | 0·364 foot |
| Form of midship section | Circle | Ellipse |
| Area of midship section | 0·256 sq. foot | 0·163 sq. foot |
| Ratio of those areas | 1: | 0·6366 |
| Form of water-lines of fore body | Harmonic curves | |
| Form of water-lines of after body | Trochoïds | |
| (Stem and stern-post at first intended to be vertical straight lines, but afterwards rounded off to prevent the corners from being chipped.) | | |
| Length of fore body: length of after body | : : 3 : 2 | 3 : 2 |
| Mean girth | 1·45 feet | 1 foot |
| Displacement when half immersed | 17·228 lb. | 10·986 lb. |

"3. Model A to be in two parts, joined at the circular midship section, so that by turning the after-body through a right angle about a longitudinal axis the water-lines can be converted into buttock-lines, and *vice versâ*.

"4. Experiments to be made according to the method formerly put in practice by Mr. Scott Russell, in which the uniformity of the propelling force is maintained by means of a regulating weight hanging from a pulley, under which the hauling cord passes; the model to be guided in a straight course by means of a stretched wire.

"5. Those experiments to be made principally at speeds not exceeding the natural speed of the wave corresponding to the length of the model, viz. about two knots per hour, or 3·38 feet per second; but a few experiments may be made at higher speeds.

"6. The experiments to be made on each model under two circumstances, viz., with the model immersed as nearly as may be to the middle water-line, and with the model totally immersed."

The programme of experiments having been thus drawn up by the Committee, the superintendence of its execution was undertaken by Mr. Scott Russell, as being the only member of the Committee resident in or near London.

Full-sized drawings of the models having been prepared in conformity with the programme, the models were made from those drawings*.

The actual execution of the experiments was entrusted by Mr. Russell to Mr. J. Quant, Naval Architect, who performed that duty with a skill and assiduity which the Committee desire to acknowledge in the highest terms.

The experiments were made upon a lake in Blackheath Park, the use of which for that purpose was liberally granted by Dr. Joseph Kidd.

A platform was laid down near the water's edge, and on it was erected a trestle; in the crosspiece at the top, two brass wheels were made to turn in sheave-holes; on the outside and against the platform in the water an oak pole was fixed, on which pole, a little above the water, another brass wheel was made to turn, care being taken that the inside of the rim of this wheel was in a perpendicular line with the outer rim of the outer wheel in the top of the crosspiece; from the oak pole to a length of about 98 feet, where another pole was fixed in the water, was stretched a wire, about 9 inches above the surface of the water, to act as guide for the model when running, two forks being fixed on the model for that purpose. At a distance of 20 feet from the outer pole was driven a stake into the bed of the lake, exposing its top above the water; at 25 feet from the first stake, a second was driven, and at 25 feet from the second, a third. In commencing an experiment, a silk cord was passed over the wheels, and, when geared round the lower wheel, the end was fixed by a hook to the model. The model was then drawn, by means of another cord, to the outer pole; and on its arrival there this cord was unhooked, and the model held by a boy seated on the top of the pole. The propelling weight was then suspended between the two top wheels in the trestle on the platform, by means of a pulley under which the cord passed; and whilst the boy yet held the model, the propelling weight was hoisted up to a height of 6 feet from the ground. The word "go" was then given, the model set free, and the propelling weight allowed to fall to within a few inches of the ground, and there held by steadily hauling in the cord till the model arrived at the platform. While the model was running, observations were taken as to the time when it

* Both drawings were exhibited at the Birmingham Meeting and also Model B. Model A, being in use, was not sent to Birmingham.

passed each post*. The first 20 feet were intended to enable the model to acquire a uniform speed by the time it arrived at the first post.

A drawing of the apparatus just described was shown at the Birmingham Meeting.

As the form of model A when half immersed is of itself unstable, it was partly hollowed out, and made stable by the help of leaden ballast. It was found impossible to make satisfactory experiments with this model at deep immersions, because it then became too heavy to be trimmed with that degree of delicacy which was requisite for the experiments. With model A therefore, the bow and stern were combined in various ways; and the under-water experiments were made with model B. This model floated exactly at half the depth when solid, and with that immersion the experiments were taken as given in the following Tables. It was afterwards hollowed out, and then loaded to such an extent as just sensibly to tend to sink. Some runs were taken with this model as deep as 15 inches; and at that time it was to a slight extent hanging on the wire, so as to meet with a little additional friction: these runs are marked with an asterisk.

While model B was being hollowed out, the run was lengthened to 150 feet, so that in each subsequent experiment four observations of speed could be made.

The following Tables show the observations as made when the models were running.

The first column gives the number of the experiment; the second column the weight suspended as before mentioned, plus the weight of the pulley and spindle, the sum being called the "propelling weight." The resistance of the model in each case was of course approximately *one-half* of this propelling weight.

The third and fourth columns give the times occupied by the model to run through the first and second spaces of 25 feet each; the fifth column gives the mean of the two former columns; the next three columns are the three preceding reduced to speed in feet per second; the next column is the mean of the runs made with the same propelling weight, in feet per second.

The phenomena that take place at high speeds are described and illustrated by sketches.

PLATE I.

Plan of the Lake "Fleur de Lis" at Blackheath, on which the experiments were taken. A is the platform on which the trestle was erected for the propelling weight. The line A B shows the guiding wire. B is the starting point from which the assistant started the models; and between A and B, parallel with the wire and about 9 inches away from it, are placed, at equal intervals, the poles which serve to mark the time of the passing models. C is the station of a boat, by means of which the assistant communicates with station B. A vertical section from A to B in this plate is given on Plate III.

PLATE II.

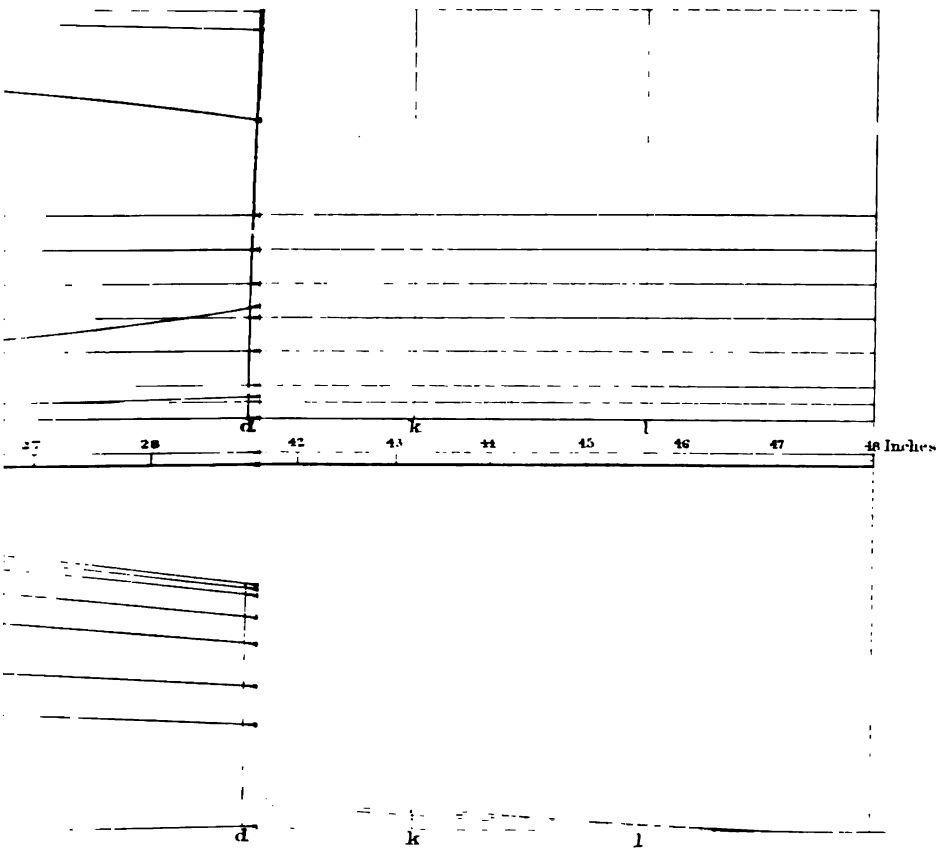
Contains the body-plan, profile, and waterlines of Model A. From aft, at the height of half the depth, the spindle is seen round which the bow or stern was turned at will as was required for the experiments.

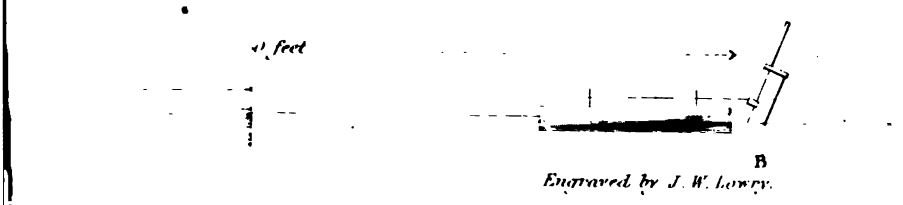
PLATE III.

The upper drawing shows the body-plan, profile, and waterlines of Model B. The waterlines of both models in the bow are pure curves of lines, and in the stern trochoids. The lower diagram on this plate represents a section of the experimental station A B shown on Plate I. A is a trestle erected to carry the propelling weight, which is maintained at the stationary height shown on the diagram; and the propelling line passes over a pulley near the level of the water.

* With a stop-watch lent for the purpose by Mr. Frodsham.

C
320
360
400 Feet
Engraved by J.W. Lowry



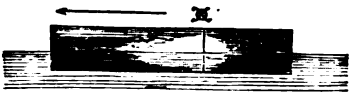

*Engraved by J. W. Lowry.*

## Model A.

| Propelling weight. | Time of first 25 feet. | Time of second 25 feet. | Mean time. | Speed of first 25 feet, in feet per second | Speed of second 25 feet, in feet per second. | Mean speed, in feet per second. | Mean of experiments. |
|---|---|---|---|---|---|---|---|
| ·437 | 13 | 12 | 12·5 | 1·92 | 2·08 | 2· | 2· |
| ·687 | 9 | 8 | 8·5 | 2·77 | 3·12 | 2·94 | 2·81 |
| | 10 | 8 | 9 | 2·5 | 3·12 | 2·81 | |
| | 9·5 | 9 | 9·25 | 2·63 | 2·77 | 2·70 | |
| 1·187 | 8 | 8 | 8 | 3·12 | 3·12 | 3·12 | 3·53 |
| | 7 | 6 | 6·5 | 3·57 | 4·16 | 3·86 | |
| | 9 | 7 | 8 | 2·77 | 3·57 | 3·17 | |
| | 8 | 6 | 7 | 3·12 | 4·16 | 3·64 | |
| | 7 | 6 | 6·5 | 3·57 | 4·16 | 3·86 | |
| 2·187 | 6 | 6 | 6 | 4·16 | 4·16 | 4·16 | 4·25 |
| | 6 | 5·5 | 5·75 | 4·16 | 4·54 | 4·35 | |
| ·437 | 14 | 13 | 13·5 | 1·78 | 1·92 | 1·9 | 1·81 |
| | 15 | 14 | 14·5 | 1·66 | 1·78 | 1·72 | |
| ·687 | 11 | 10 | 10·5 | 2·27 | 2·5 | 2·38 | 2·32 |
| | 12 | 9·5 | 10·75 | 2·08 | 2·63 | 2·35 | |
| | 12·5 | 10 | 11·25 | 2 | 2·5 | 2·25 | |
| ·437 | 12 | 13 | 12·5 | 2·08 | 1·92 | 2 | 1·82 |
| | 13 | 13 | 13 | 1·92 | 1·92 | 1·92 | |
| | 13·5 | 13 | 13·25 | 1·9 | 1·92 | 1·96 | |
| | 14 | 13·5 | 13·75 | 1·78 | 1·9 | 1·84 | |
| | 15 | 14 | 14·5 | 1·66 | 1·78 | 1·72 | |
| | 15 | 15 | 15 | 1·66 | 1·66 | 1·66 | |
| | 14 | 13 | 13·5 | 1·78 | 1·92 | 1·85 | |
| | 14 | 13 | 13·5 | 1·78 | 1·92 | 1·85 | |
| | 10·5 | 10·2 | 10·35 | 2·38 | 2·45 | 2·41 | |
| ·687 | 11 | 9·5 | 10·25 | 2·27 | 2·63 | 2·45 | 2·49 |
| | 10·5 | 9·5 | 10 | 2·38 | 2·63 | 2·50 | |
| | 10 | 9·5 | 9·75 | 2·5 | 2·63 | 2·56 | |
| | 10 | 9·5 | 9·75 | 2·5 | 2·63 | 2·56 | |
| | 8 | 7·5 | 7·75 | 3·12 | 3·33 | 3·22 | |
| 1·187 | 8·5 | 7·8 | 8·15 | 2·94 | 3·34 | 3·14 | 3·37 |
| | 7·5 | 6·75 | 7·12 | 3·33 | 3·70 | 3·51 | |
| | 7·5 | 7 | 7·25 | 3·33 | 3·57 | 3·45 | |
| | 8 | 7 | 7·5 | 3·12 | 3·57 | 3·34 | |
| | 8 | 7 | 7·5 | 3·12 | 3·57 | 3·34 | |
| | 7·5 | 7 | 7·25 | 3·33 | 3·57 | 3·45 | |
| 187 | 6 | 5·5 | 5·75 | 4·16 | 4·54 | 4·35 | 4·39 |
| | 6 | 5·5 | 5·75 | 4·16 | 4·54 | 4·35 | |
| | 5·5 | 5·5 | 5·5 | 4·54 | 4·54 | 4·54 | |
| | 6 | 5·5 | 5·75 | 4·16 | 4·54 | 4·35 | |
| ·437 | 18· | 15 | 16·5 | 1·38 | 1·66 | 1·52 | 1·59 |
| | 16·5 | 14·5 | 15·5 | 1·66 | 1·72 | 1·69 | |
| | 16·5 | 14·75 | 15·62 | 1·66 | 1·7 | 1·68 | |
| | 16·5 | 15·5 | 16 | 1·66 | 1·61 | 1·63 | |
| | 17 | 15·5 | 16·25 | 1·47 | 1·61 | 1·54 | |
| | 17·5 | 15·2 | 16·35 | 1·42 | 1·64 | 1·53 | |
| ·687 | 13 | 11·75 | 12·37 | 1·92 | 2·12 | 2·02 | 2·03 |
| | 13 | 11·6 | 12·3 | 1·92 | 2·15 | 2·03 | |
| | 12 | 11·8 | 11·9 | 2·08 | 2·11 | 2·09 | |
| | 13·5 | 11·5 | 12·5 | 1·9 | 2·17 | 2·03 | |
| | 13 | 11·6 | 12·3 | 1·92 | 2·15 | 2·03 | |
| | 12·5 | 12·2 | 12·35 | 2 | 2·04 | 2·02 | |

*Position* 1, *a*.

Area of immersed section = 0·14 square foot. Weight of model, 18·728 lb.

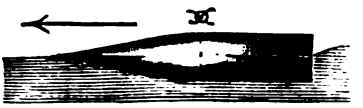


*Position* 2, *b*.

Area of immersed section = 0·128 square foot. Weight of model, 17·228 lb.

*Position* 3, *c*.

Area of immersed section = 0·128 square foot. Weight of model, 17·228 lb.

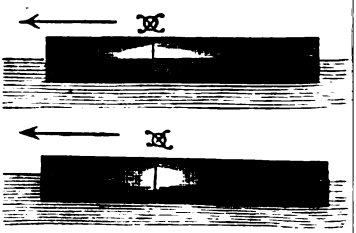


*Position* 4, *d*.

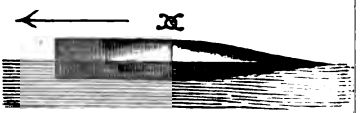
Area of immersed section = 0·128 square foot. Weight of model, 17·228 lb.

| Number of experiment. | Propelling weight. | Time of first 25 feet. | Time of second 25 feet. | Mean time. | Speed of first 25 feet, in feet per second. | Speed of second 25 feet, in feet per second. | Mean speed, in feet per second. | Mean of experiments. |
|---|---|---|---|---|---|---|---|---|
| 53. | | 12 | 11 | 11·5 | 2·08 | 2·27 | 2·17 | |
| 54. | | 13·5 | 13·2 | 13·35 | 1·85 | 1·76 | 1·80 | |
| 55. | | 12 | 10·5 | 11·25 | 2·08 | 2·38 | 2·23 | |
| 56. | | 13 | 11 | 12 | 1·92 | 2·27 | 2·09 | |
| 57. | ·437 | 14·5 | 12 | 13·25 | 1·72 | 2·08 | 1·90 | 1·98 |
| 58. | | 14 | 13·5 | 13·75 | 1·78 | 1·85 | 1·81 | |
| 59. | | 12·5 | 11·2 | 11·85 | 2 | 2·23 | 2·11 | |
| 60. | | 14·5 | 13 | 13·75 | 1·72 | 1·92 | 1·82 | |
| 61. | | 13·5 | 12·5 | 13 | 1·85 | 2 | 1·92 | |
| 62. | | 10·5 | 10 | 10·25 | 2·38 | 2·5 | 2·44 | |
| 63. | | 10 | 8·5 | 9·25 | 2·5 | 2·94 | 2·72 | |
| 64. | | 10 | 9·5 | 9·75 | 2·5 | 2·63 | 2·56 | |
| 65. | ·687 | 10 | 9 | 9·5 | 2·5 | 2·77 | 2·63 | |
| 66. | | 9 | 9 | 9 | 2·77 | 2·77 | 2·77 | 2·54 |
| 67. | | 10 | 10 | 10 | 2·5 | 2·5 | 2·5 | |
| 68. | | 11·5 | 10·5 | 11 | 2·17 | 2·38 | 2·27 | |
| 69. | | 10 | 10 | 10 | 2·5 | 2·5 | 2·5 | |
| 70. | | 9 | 8 | 8·5 | 2·77 | 3·12 | 2·94 | |
| 71. | | 8 | 8 | 8 | 3·12 | 3·12 | 3·12 | |
| 72. | | 8·5 | 7·5 | 8 | 2·94 | 3·33 | 3·13 | |
| 73. | 1·187 | 9 | 8 | 8·5 | 2·77 | 3·12 | 2·94 | |
| 74. | | 7·5 | 7·2 | 7·35 | 3·33 | 3·47 | 3·40 | 3·19 |
| 75. | | 7 | 6·75 | 6·87 | 3·57 | 3·70 | 3·63 | |
| 76. | | 8·5 | 8 | 8·25 | 2·94 | 3·12 | 3·03 | |
| 77. | | 8 | 7 | 7·5 | 3·12 | 3·57 | 3·34 | |
| 78. | | 6 | 6 | 6 | 4·16 | 4·16 | 4·16 | |
| 79. | | 6 | 6 | 6 | 4·16 | 4·16 | 4·16 | |
| 80. | 2·187 | 6 | 6 | 6 | 4·16 | 4·16 | 4·16 | |
| 81. | | 6 | 6 | 6 | 4·16 | 4·16 | 4·16 | 4·16 |
| 82. | | 6 | 6 | 6 | 4·16 | 4·16 | 4·16 | |
| 83. | | 6 | 6 | 6 | 4·16 | 4·16 | 4·16 | |
| 84. | | 13 | 12 | 12·5 | 1·92 | 2·08 | 2 | |
| 85. | ·437 | 14 | 13 | 13·5 | 1·78 | 1·92 | 1·90 | |
| 86. | | 15 | 14 | 14·5 | 1·66 | 1·78 | 1·72 | 1·83 |
| 87. | | 15 | 14 | 14·5 | 1·66 | 1·78 | 1·72 | |
| 88. | | 13 | 12 | 12·5 | 1·92 | 2·08 | 2 | |
| 89. | ·687 | 14 | 13 | 13·5 | 1·78 | 1·92 | 1·81 | |
| 90. | | 13 | 13 | 13 | 1·92 | 1·92 | 1·92 | 1·88 |
| 91. | | 14·5 | 13 | 13·75 | 1·72 | 1·92 | 1·82 | |
| 92. | | 10 | 11 | 11·5 | 2·5 | 2·08 | 2·29 | |
| 93. | 1·187 | 10·5 | 10 | 10·25 | 2·38 | 2·5 | 2·42 | |
| 94. | | 10·5 | 10 | 10·25 | 2·38 | 2·5 | 2·42 | 2·37 |
| 95. | | 8·5 | 8 | 8·25 | 2·94 | 3·12 | 3·03 | |
| 96. | 2·187 | 9 | 8 | 8·5 | 2·76 | 3·12 | 2·94 | |
| 97. | | 8 | 8 | 8 | 3·12 | 3·12 | 3·12 | 3·03 |

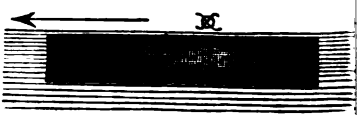
*Position* 5, *e*.
Area of immersed section = 0·4 square foot. Weight of model in lb 18·728.



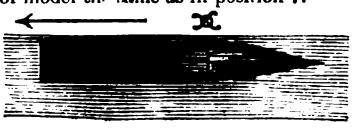
*Position* 6, *f*.
Area of immersed section = 0·12 square foot. Weight of model in lb 17·228.



*Position* 7, *g*.
Area of immersed section = 0·25 square foot. Weight of model, 34·4 lb.



| Number of experiment. | Propelling weight. | Time of first 25 feet. | Time of second 25 feet. | Mean time. | Speed of first 25 feet, in feet per second. | Speed of second 25 feet, in feet per second. | Mean speed, in feet per second. | Mean of experiments. | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | *Position* 8, *h*. Area of immersed section and weight of model the same as in position 7. |
| 98. | 1·187 | 13 | 13 | 13 | 1·92 | 1·92 | 1·92 | 2·01 | |
| 99. | | 12 | 11 | 11·5 | 2·08 | 2·27 | 2·17 | | |
| 00. | | 12 | 14 | 13 | 2·08 | 1·78 | 1·93 | | |
| 01. | 2·187 | 8 | 8 | 8 | 3·12 | 3·12 | 3·12 | 3·12 | |
| 02. | | 8 | 8 | 8 | 3·12 | 3·12 | 3·12 | | |



*Remarks on Model A.*

In Position 1 the model at high speeds raised waves before and behind.

In Position 2 higher speeds were impracticable, the stern lifting itself out of the water; in fact, with the propelling weight ·687 lb., there was a little wave propagated. In this position the model was exactly half trim, there being ample stability in this position.

In Position 3, with the last propelling weight, a beautiful wave was formed, also with the last weight but one, but not so large.

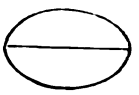
In Position 4 further experiments were fruitless. Its path or course was so irregular that taking down quantities was impossible. It may, however, be remarked, comparing Position No. 3 with Position No. 4, that the latter has more resistance than the former.

In Position 5, with a propelling weight of ·687 lb., a wave was formed as shown in the sketch, and these waves became larger as the propelling weight increased.

In Position 6 further experiments were abandoned, the phenomena being the same as in Position No. 2.

## Model B.

| Number of experiment. | Propelling weight. | Time of first 25 feet. | Time of second 25 feet. | Mean time. | Speed of first 25 feet, in feet per second. | Speed of second 25 feet, in feet per second. | Mean speed, in feet per second. | Mean of experiments. |
|---|---|---|---|---|---|---|---|---|
| 103. | | 13 | 12 | 12·5 | 1·92 | 2·08 | 2 | |
| 104. | | 12·5 | 12 | 12·25 | 2 | 2·08 | 2·04 | |
| 105. | ·437 | 15 | 14 | 14·5 | 1·66 | 1·78 | 1·72 | 1·90 |
| 106. | | 14·5 | 13 | 13·75 | 1·72 | 1·92 | 1·82 | |
| 107. | | 13 | 13 | 13 | 1·92 | 1·92 | 1·92 | |
| 108 | | 9 | 8 | 8·5 | 2·77 | 3·12 | 2·94 | |
| 109. | | 10 | 9 | 9·5 | 2·5 | 2·77 | 2·63 | |
| 110. | | 8 | 7 | 7·5 | 3·12 | 3·57 | 3·34 | |
| 111. | | 10 | 9 | 9·5 | 2·5 | 2·77 | 2·63 | |
| 112. | ·687 | 9 | 8 | 8·5 | 2·77 | 3·12 | 2·94 | 2·99 |
| 113. | | 8 | 9 | 8·5 | 3·12 | 2·77 | 2·94 | |
| 114. | | 7 | 9 | 8 | 3·57 | 2·77 | 3·17 | |
| 115. | | 9 | 8 | 8·5 | 2·77 | 3·12 | 2·94 | |
| 116. | | 8 | 10 | 9 | 3·12 | 2·5 | 2·81 | |
| 117. | | 10 | 9 | 9·5 | 2·5 | 2·77 | 2·63 | |
| 118. | | 6·5 | 6 | 6·25 | 3·84 | 4·16 | 4 | |
| 119. | 1·187 | 7 | 6 | 6·5 | 3·57 | 4·16 | 3·86 | 3·95 |
| 120. | | 6·5 | 6 | 6·25 | 3·84 | 4·16 | 4 | |
| 121. | | 4·5 | 4 | 4·25 | 5·55 | 6·25 | 5·9 | |
| 122. | 2·187 | 6 | 5 | 5·5 | 4·16 | 5 | 4·58 | |
| 123. | | 5·5 | 5 | 5·25 | 4·54 | 5 | 4·77 | 4·95 |
| 124. | | 6 | 5 | 5·5 | 4·16 | 5 | 4·58 | |



*Position* 1, *i*.
Area of immersed midship section = 0·0816 square foot. Weight of model = 10·986 lb.

With the propelling weight 1·187 lb. the model raised a wave in the bow and stern; and these waves became larger as the weight increased.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 125. | | 10·5 | 10 | 9·75 | 2·38 | 2·5 | 1·44 | |
| 126. | | 13 | 13 | 13 | 1·92 | 1·92 | 1·92 | |
| 127. | | 12·5 | 11·5 | 12 | 2 | 2·17 | 2·08 | |
| 128. | ·437 | 11 | 10 | 10·5 | 2·27 | 2·5 | 2·38 | 2·11 |
| 129. | | 11 | 10 | 10·5 | 2·27 | 2·5 | 2·38 | |
| 130. | | 11·5 | 11 | 11·25 | 2 | 2·27 | 2·13 | |
| 131. | | 11 | 9·5 | 10·25 | 2·27 | 2·63 | 2·45 | |
| 132. | | 8·5 | 8 | 8·25 | 2·94 | 3·12 | 3·03 | |
| 133. | | 9 | 8·5 | 8·75 | 2·77 | 2·94 | 2·85 | |
| 134. | ·687 | 9 | 8 | 8·5 | 2·77 | 3·12 | 2·94 | 2·94 |
| 135. | | 8·5 | 8 | 8·25 | 2·94 | 3·12 | 3 03 | |
| 136. | | 9 | 8·5 | 8·75 | 2·77 | 2·94 | 2·86 | |
| 137. | | 8 | 7 | 7·5 | 3·12 | 3·57 | 3·34 | |
| 138. | | 7·5 | 7 | 7·25 | 3·33 | 3·57 | 3·45 | |
| 139. | | 6·4 | 6 | 6·2 | 3·9 | 4·16 | 4·03 | |
| 140. | 1·187 | 7 | 6·4 | 6·7 | 3·57 | 3 9 | 3·73 | 3·54 |
| 141. | | 8 | 7 | 7·5 | 3·12 | 3·57 | 3·34 | |
| 142. | | 7·5 | 6·8 | 7·15 | 3·33 | 3·68 | 3·50 | |
| 143. | | 8 | 7·5 | 7·75 | 3·12 | 3·33 | 3·22 | |
| 144. | | 7 | 8 | 7·5 | 3·57 | 3·12 | 3·73 | |

*Position* 2, *k*.
Area of immersed midship section = 0·0816 square foot. Weight of model, 10·986 lb.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 145. | | 6·5 | 5 | 5·75 | 3·86 | 5 | 4·43 | |
| 146. | | 5·5 | 5 | 5·25 | 4·54 | 5 | 4·77 | |
| 147. | 2·187 | 6 | 5·25 | 5·62 | 4·16 | 4·76 | 4·46 | 4·66 |
| 148. | | 5·5 | 5 | 5·25 | 4·54 | 5 | 4·77 | |
| 149. | | 5·5 | 5 | 5·25 | 4·54 | 5 | 4·77 | |
| 150. | | 5·5 | 5 | 5·25 | 4·54 | 5 | 4·77 | |

From the propelling weight ·687 lb. upwards, the model raised waves; and those waves became larger as the speed increased, and spread themselves horizontally in the form of a wave-line.

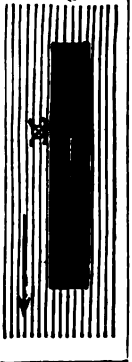
| | Propelling weight. | Time of first 25 feet. | Time of second 25 feet. | Time of third 25 feet. | Time of fourth 25 feet. | Mean time. | Speed of first 25 feet, in feet per second. | Speed of second 25 feet, in feet per second. | Speed of third 25 feet, in feet per second. | Speed of fourth 25 feet, in feet per second. | Mean speed, in feet per second. | Mean of experiments. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | | 14·5 | 14 | 12·5 | 12 | 13·25 | 1·72 | 1·78 | 2 | 2·08 | 1·89 | | |
| 2. | | 14 | 14 | 13 | 12 | 13·25 | 1·78 | 1·78 | 1·92 | 2·63 | 2·02 | | |
| 3. | | 14 | 12 | 12 | 11 | 12·5 | 1·78 | 1·92 | 2·08 | 2·27 | 2·01 | | |
| 4. | | 14 | 13·5 | 13 | 12 | 13·1 | 1·78 | 1·9 | 1·92 | 2·63 | 1·91 | | |
| 5. | | 13 | 11·5 | 11 | 10 | 11·37 | 1·92 | 2·29 | 2·27 | 2·5 | 2·24 | | |
| 6. | | 14 | 12·5 | 11 | 10 | 11·87 | 1·78 | 2 | 2·27 | 2·5 | 2·13 | | |
| 7. | | 13·5 | 12·5 | 12 | 11 | 12·25 | 1·9 | 2 | 2·63 | 2·27 | 2·20 | | |
| 8. | ·437 | 14 | 13 | 13 | 12·5 | 13·12 | 1·78 | 1·92 | 1·92 | 2 | 1·90 | 1·98 | |
| 9. | | 14·5 | 14 | 13 | 12·5 | 13·5 | 1·72 | 1·78 | 1·92 | 2 | 1·85 | | |
| 10. | | 15 | 14 | 14 | 13·5 | 14·12 | 1·66 | 1·78 | 1·78 | 1·9 | 1·78 | | |
| 11. | | 15 | 14 | 13 | 12 | 13·5 | 1·66 | 1·78 | 1·92 | 2·63 | 1·99 | | |
| 12. | | 15 | 15 | 13·5 | 12 | 13·87 | 1·66 | 1·66 | 1·9 | 2·63 | 1·96 | | |
| 13. | | 15 | 14 | 12 | 11·5 | 13·12 | 1·66 | 1·73 | 2·63 | 2·29 | 2·09 | | |
| 14. | | 14·5 | 14·5 | 13·5 | 12·75 | 13·81 | 1·72 | 1·72 | 1·9 | 1·96 | 1·82 | | |
| 15. | | 11 | 10·8 | 8·5 | 8 | 9·57 | 2·27 | 2·32 | 2·94 | 3·12 | 2·66 | | |
| 16. | | 12·5 | 11 | 9·5 | 8·5 | 10·37 | 2 | 2·27 | 2·63 | 2·94 | 2·46 | | |
| 17. | | 11 | 10·5 | 9·5 | 8 | 9·5 | 2·27 | 2·47 | 2·63 | 3·12 | 2·62 | | |
| 18. | | 11 | 10 | 9 | 8·8 | 9·7 | 2·27 | 2·5 | 2·77 | 2·84 | 2·59 | | |
| 19. | ·687 | 12 | 11 | 9·5 | 8 | 10·12 | 2·08 | 2·27 | 2·63 | 3·12 | 2·52 | 2·62 | |
| 70. | | 11·5 | 10 | 9·5 | 8 | 9·5 | 2·17 | 2·5 | 2·63 | 3·12 | 2·60 | | |
| 71. | | 10 | 9·5 | 9 | 8·5 | 9·25 | 2·5 | 2·63 | 2·77 | 2·94 | 2·71 | | |
| 72. | | 10·5 | 9 | 9 | 8·5 | 9·25 | 2·47 | 2·77 | 2·77 | 2·94 | 2·74 | | |

The position, the area of the immersed section, and the weight of model, as Position 1.

The experiments from No. 151 to No. 172 were taken with the lengthened run. The acceleration with the larger weight was nearly one second every five and twenty feet; hence the difference when the quantities are compared with Position 1. The unseasonable weather made it necessary to stop the above experiments and commence those in which the model was entirely immersed.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 173. | | 19·4 | 19·6 | 20 | 20·2 | 19·8 | 1·29 | 1·26 | 1·25 | 1·23 | 1·25 | | |
| 174. | | 21·2 | 21·6 | 20·6 | 21·4 | 21·2 | 1·18 | 1·15 | 1·21 | 1·17 | 1·17 | | |
| 175. | | 19·2 | 19·6 | 20·4 | 20·6 | 19·95 | 1·30 | 1·26 | 1·22 | 1·21 | 1·25 | | |
| 176. | ·437 | 19·7 | 19·8 | 19 | 19·5 | 19·5 | 1·26 | 1·26 | 1·31 | 1·27 | 1·27 | 1·24 | |
| 177. | | 19·8 | 21· | 20·6 | 21·2 | 20·65 | 1·26 | 1·19 | 1·21 | 1·18 | 1·21 | | |
| 178. | | 20·4 | 19·2 | 18·8 | 19·4 | 19·45 | 1·22 | 1·30 | 1·33 | 1·29 | 1·28 | | |
| 179. | | 11·6 | 11·8 | 12·6 | 13·8 | 12·45 | 2·15 | 2·11 | 1·98 | 1·80 | 2·01 | 1·56 | |
| 180. | | 16·4 | 17·2 | 16·8 | 20 | 17·6 | 1·52 | 1·45 | 1·49 | 1·25 | 1·42 | | |
| 181. | | 13 | 12·8 | 12·1 | 12·5 | 12·6 | 1·92 | 1·95 | 2·06 | 2· | 1·98 | | |
| 182. | | 15·8 | 15·6 | 14·6 | 15·4 | 15·35 | 1·51 | 1·6 | 1·71 | 1·62 | 1·64 | | |
| 183. | ·687 | 11·2 | 15·8 | 14·8 | 14·4 | 14·05 | 2·23 | 1·64 | 1·70 | 1·72 | 1·82 | | |
| 184. | | 18·8 | 16 | 11·6 | lost | 15·46 | 1·33 | 1·56 | 2·15 | ... | 1·68 | | |
| 185. | | 22·9 | 27·2 | 32·4 | 25·5 | 27 | 1·09 | 0·91 | 0·77 | 0·98 | 0·94 | | |
| 186. | | 19·8 | 29·8 | 32·6 | 21·4 | 25·9 | 1·26 | 0·83 | 0·76 | 1·16 | 1· | | |
| 187. | | 23 | 16 | 14·2 | 14· | 16·8 | 1·08 | 1·56 | 1·76 | 1.78 | 1·54 | | |
| 188. | | 11·3 | 11·2 | 10·2 | 10·4 | 10·77 | 2·21 | 2·23 | 2·45 | 2·40 | 2·32 | | |
| 189. | | 10·1 | 10 | 10 | 9·2 | 9·82 | 2·47 | 2·5 | 2·5 | 2·71 | 2·54 | | |
| 190. | | 9·8 | 9·4 | 8·8 | 8·8 | 9·2 | 2·55 | 2·66 | 2·84 | 2·84 | 2·72 | | |
| 191. | | 11·2 | 11 | 10·8 | 9·8 | 10·7 | 2·23 | 2·27 | 2·32 | 2·55 | 2·34 | | |
| 192. | 1·187 | 12·2 | 10·4 | 10·6 | 10·4 | 10·9 | 2·04 | 2·40 | 2·36 | 2·40 | 2·30 | 2·25 | |
| 193. | | 11 | 11·6 | 10·2 | 10·4 | 10·8 | 2·27 | 2·15 | 2·45 | 2·40 | 2·31 | | |
| 194. | | 13·6 | 14·4 | 13·6 | 13·8 | 13·85 | 1·83 | 1·73 | 1·83 | 1·09 | 1·62 | | |
| 195. | | 13·5 | 13·2 | 13·4 | 13·6 | 13·42 | 1·85 | 1·90 | 1·87 | 1·90 | 1·88 | | |
| 196. | | 8 | 9 | 8·6 | 8·6 | 8·55 | 3·12 | 2·77 | 2·90 | 2·90 | 2·90 | | |
| 197. | | 9·4 | 9·6 | 9 | 9 | 9·25 | 2·55 | 2·60 | 2·77 | 2·77 | 2·70 | | |
| 198. | | 10·4 | 11 | 10 | 9·6 | 10·25 | 2·41 | 2·27 | 2·5 | 2·60 | 2·44 | | |
| 199. | 2·187 | 10·4 | 11 | 10 | 10·6 | 10·5 | 2·41 | 2·27 | 2·5 | 2·36 | 2·38 | 2·71 | |
| 200. | | 11·8 | 12·2 | 11·2 | 11 | 11·55 | 2·11 | 2·04 | 2·23 | 2·27 | 2·16 | | |
| 201. | | 7·4 | 7·2 | 6·2 | 6 | 6·7 | 3·38 | 3·47 | 4·03 | 4·16 | 3·76 | | |

* Without 185 and 186 the mean is 1·72.



Area of immersed midship section = 0·163 square foot. Weight of model, 22 lbs.

| Number of experiment. | Propelling weight. | Time of first 25 feet. | Time of second 25 feet. | Time of third 25 feet. | Time of fourth 25 feet. | Mean time. | Speed of first 25 feet, in feet per second. | Speed of second 25 feet, in feet per second. | Speed of third 25 feet, in feet per second. | Speed of fourth 25 feet, in feet per second. | Mean speed, in feet per second. | Mean of experiments. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 202. | | 15·8 | 15·2 | 15·6 | 15·8 | 15·6 | 1·51 | 1·6 | 1·6 | 1·51 | 1·55 | |
| 203. | | 12·6 | 12·8 | 11·8 | 12 | 12·25 | 1·98 | 1·95 | 2·15 | 2·5 | 2·14 | |
| 204. | ·687 | 12·6 | 14·4 | 13·8 | 14·6 | 13·85 | 1·98 | 1·72 | 1·09 | 1·71 | 1·62 | 1·72 |
| 205. | | 14·2 | 15·4 | 15·4 | 15·8 | 15·2 | 1·76 | 1·62 | 1·62 | 1·51 | 1·62 | |
| 206. | | 14·8 | 14·8 | 14·2 | 14·6 | 14·6 | 1·7 | 1·7 | 1·76 | 1·71 | 1·71 | |
| 207. | | 12·2 | 11 | 10·4 | 9·6 | 10·8 | 2·04 | 2·27 | 2·4 | 2·60 | 2·31 | |
| 208. | | 10·6 | 11·6 | 9·2 | 10·2 | 10·4 | 2·36 | 2·15 | 2·71 | 2·45 | 2·41 | |
| 209. | | 10·8 | 10·6 | 10·6 | 8·8 | 10·2 | 2·32 | 2·36 | 2·36 | 2·84 | 2·47 | |
| 210. | 1·187 | 11·2 | 9·6 | 10·2 | 9·8 | 10·2 | 2·23 | 2 | 2·45 | 2·55 | 2·45 | 2·45 |
| 211. | | 10 | 9·8 | 10 | 10 | 9·95 | 2·5 | 2·55 | 2·5 | 2·5 | 2·51 | |
| 212. | | 10·8 | 10·4 | 9·2 | 9·4 | 9·85 | 2·4 | 2·4 | 2·71 | 2·66 | 2·54 | |
| 213. | | 11·2 | 10·2 | 10 | 9·4 | 10·2 | 2·23 | 2·45 | 2·5 | 2·66 | 2·46 | |
| 214. | | 7·8 | 7·6 | 8 | 7·8 | 7·8 | 3·21 | 3·28 | 3·12 | 3·21 | 3·20 | |
| 215. | | 7·2 | 7·6 | 7·8 | 8·6 | 7·8 | 3·47 | 3·28 | 3·21 | 2·9 | 3.21 | |
| 216. | | 7·6 | 7·8 | 7·6 | 7 | 7·5 | 3·28 | 3·21 | 3·28 | 3·57 | 3·33 | |
| 217. | 2·187 | 7·6 | 7·8 | 7 | 7·6 | 7·5 | 3·28 | 3·21 | 3·57 | 3·28 | 3·33 | 3·26 |
| 218. | | 7·8 | 7·6 | 7·6 | 7·4 | 7·6 | 3·21 | 3·28 | 3·28 | 3·38 | 3·28 | |
| 219. | | 8·0 | 7·4 | 7·4 | 7·6 | 7·6 | 3·12 | 3·38 | 3·38 | 3·28 | 3·29 | |
| 220. | | 7·8 | 7·8 | 7·6 | 8 | 7·8 | 3·21 | 3·21 | 3·28 | 3·12 | 3·20 | |

The area of the midship section, and the weight of the model were the same as in the preceding Table.

## SUMMARY.

### Model A.

| | | | | Speed, in feet per second. | | | |
|---|---|---|---|---|---|---|---|
| *a.* | Half immersed. | Stem and stern vertical, bow foremost ..... | 2 | 2·81 | 3·53 | 4·25 |
| *b.* | „ „ | Stem vertical, stern horizontal. „ ... | 1·81 | 2·32 | | |
| *c.* | „ „ | Stem horizontal, stern vertical. „ ... | 1·82 | 2·49 | 3·37 | 4·39 |
| *d.* | „ „ | Stem and stern horizontal. „ ... | 1·59 | 2·03 | | |
| *e.* | „ „ | Stem and stern vertical, stern foremost ..... | 1·98 | 2·54 | 3·19 | 4·16 |
| *f.* | „ „ | Stem horizontal, stern vertical, stern foremost | 1·83 | | | |
| *g.* | Wholly immersed. | Stem and stern vertical, bow foremost ..... | ... | 1·88 | 2·37 | 3·03 |
| *h.* | „ „ | Stem vertical, stern horizontal, bow foremost | ... | ... | 2·01 | 3·12 |

### Model B.

| | | | Speed, in feet per second. | | | |
|---|---|---|---|---|---|---|
| *i.* | Half immersed. | Stem and stern vertical, bow foremost ..... | 1·90 | 2·99 | 3·95 | 4·95 |
| *k.* | „ „ | „ „ „ stern „ ... | 2·11 | 2·94 | 3·54 | 4·66 |
| *m.* | Wholly immersed. | „ „ „ bow „ ... | 1·24 | 1·56 | 2·25 | 2·71 |
| *n.* | „ „ | „ „ „ stern „ ... | ... | 1·72 | 2·45 | 3·26 |

In the preceding statement the Committee have given simply the observed facts, deferring for the present to draw from them any general conclusions.

## *Report on Muscular Irritability and the relations which exist between Muscle, Nerve, and Blood. By* RICHARD NORRIS, *M.D.*

MUSCULAR irritability is commonly recognized and defined as that property of muscular tissue by virtue of which it contracts under the influence of stimuli.

This property is said by Du Bois Reymond to bear a definite relation to its electromotor powers. He says, "the diminution of the muscular current after death is proportional to the diminution of the excitability of the muscle; both the electromotor force and the excitability have the same termination, *i. e.* in the rigor mortis, caused, as Brueck has proved, by the coagulation of the fibrin contained in the muscles external to the blood-vessels." As a general summary of his researches on this question, Du Bois Reymond again says, "the electric power of a muscle is always proportioned to its contractility, inasmuch as those agents which do not influence its contractility exert no influence on its current."

Matteucci has asserted "that the muscular current continually decreases *after the death of the animal*, or after *the separation of the muscle* from the body"*.

Taken in concert, these statements of Matteucci and Reymond amount to this: muscular irritability continually decreases after the removal of a muscle from nervous and blood influences. This view of the gradual decline of muscular irritability after somatic death is concurred in by physiologists generally. Certain researches in which the author of this paper has been long engaged, have led him to doubt the accuracy of this conclusion as a necessary and fundamental truth.

As the consideration of the subject opens up a considerable range of ex-

* By the death of an animal the author of this paper understands the loss of the property of excitability or neurility on the part of the ganglionic nervous masses, without power of restoration, in fact molecular death of the vesicular nervous tissue. It is certain that the phenomena of life, as manifested by animals, may be again aroused into exhibition so long as the *capacity* for molecular life persists in the nervous system, notwithstanding that both respiration and circulation may have long ceased. In a chapter on death, p. 905 of Carpenter's 'Principles of Human Physiology,' the following passage occurs:—"A surer test, however, is afforded by the condition of the *muscular* substance; for this gradually loses its irritability after real death, so that it can no longer be excited to contraction by electrical or other kind of stimulation; and the loss of irritability is succeeded by the appearance of cadaveric rigidity. So long, then, as the muscle retains its irritability and remains free from rigidity, so long we may say with certainty that it is *not dead*; and the persistence of its vitality for an unusual period affords a presumption in favour of the continuance of some degree of vital action in the body generally; whilst, on the other hand, the entire loss of irritability and the supervention of rigidity afford conclusive evidence that death has occurred."

On this the present writer would remark that although the persistence of muscular irritability affords strong presumptive evidence of the existence of systemic life, yet it cannot be invariably relied upon, inasmuch as the irritability may in cases of excessive interstitial change increase after the *molecular death of the nervous masses and the final arrest of the blood-current*. On the other hand, universal rigor mortis, the result of the absence of blood or suitable nutritional plasma, is a certain evidence of death whenever the circumstances of the case imply that the nervous system has also been subjected to a simultaneous absence of its *proper* nutrition, inasmuch as it appears to be a law without exception, that, if muscular and nervous tissues be simultaneously shut off from their source of nutrition, the molecular life of the nervous tissue is the first to succumb. It is, however, possible to conceive of certain spasmodic affections of the minute arteries supplying muscular tissue in warm bloods inducing rigor rapidly, in the same manner as deligation of arterial trunks; and if at the same time it should happen from any collateral circumstance that this condition of vascular spasm did not extend to the nervous masses, somatic death would not necessarily be implied even by the existence of rigor. Universal putrescence is therefore the only *absolute* evidence of death.

perimental inquiry, it is conceived that it may be most efficiently discussed in its various bearings by an attempt to support the following propositions, mainly derived from the study of phenomena which are best and most constantly seen in cold-blooded animals, but which nevertheless, under favourable circumstances, may be observed in warm-bloods, and, in special pathological conditions, in the case of man himself:—

1. That the property of irritability in muscle is capable of a high degree of exaltation above the normal standard, and that the highest degree of susceptibility is attained in cold-bloods long after death, or under conditions tantamount to death, as before defined.

2. That the forces of nerve and muscle, the neurility of the former and the irritability of the latter, are not only independent of each other for their existence and maintenance, but actually possess an antagonistic relation; that is to say, nerve-tissue, instead of producing, is, when in action, constantly concerned in maintaining a condition of things which diminishes muscular irritability, and that not simply when it is engaged in the production of motion. Hence muscular tissue, relieved from the operation or influence of nerve-tissue, gradually acquires exalted contractile powers either in the presence or absence of the blood.

3. That the blood, or the nutritional plasma derived therefrom, not only furnishes the materials by which muscular irritability is maintained, but is likewise the determining cause of that polar arrangement of the muscular molecules which maintains or restores the elongated or relaxed state.

It is a well-observed fact in physiology, that after the death of animals the irritability of the muscles frequently exhibits itself in an abnormal manner. In the living animal or the amputated limb, the contractions which are inducible by the application of stimuli, such as galvanism, pinching, or striking, are of a pulsatory character; that is to say, the contraction is limited in extent and speedily gives place to relaxation; but in the cases where the peculiarity alluded to is present, the contractions following on such stimuli are more extensive and persistent, and simulate very perfectly contraction induced by volition. The same peculiar exalted susceptibility has also been witnessed in man after death from certain forms of disease, more particularly in cholera and yellow fever.

Dr. Bennett Dowler, by experimenting upon amputated limbs, proved the dependence of this phenomenon upon muscular irritability alone. It is asserted, not only that in some of these cases the movements can be excited by mechanical stimulation, but that they not unfrequently occur spontaneously, and strongly resemble the actions of the living state. Carpenter quotes the case of an Irishman, aged 28, in whom the following series of movements took place spontaneously not long after the cessation of the respiration:—"First the left hand was carried by a regular motion to the throat and then to the crown of the head; the right arm followed the same route on the right side; the left arm was then carried back to the throat and from thence to the breast, reversing all its original motions, and finally the right hand and arm did exactly the same." This hyper-irritable condition of the muscular system attracted the notice of Dr. Brown Sequard, and he found it to present itself more constantly in young animals. This experience of Brown Sequard's is conformable with my own; but I have also been fortunate enough to observe it in cold-bloods with sufficient frequency to enable me to study it. It is well known that in many particulars the young of warm-bloods are analogous to the cold-bloods; and one of these is the length of time that muscular irritability persists.

I will now cite two or three experiments in illustration of this exalted state.

April 7, 1863.—A frog carefully etherized, was placed upon his back, and the heart was excised. The frog was then left till the following morning, a period of 13 hours. At this time the webs and toes were in a dried state; but the muscles responded with extreme readiness to slight blows, but were not thrown into contraction when pinched by forceps. They were very susceptible to weak galvanism. These observations on the muscular system having been made, the nervous system was tested by removing the head and attempting to irritate the cord. Galvanizing the cord would not excite the muscles even when a copper wire was thrust low down into its substance. The cord, in fact, seemed quite incapable of either initiating or conveying any stimulus to the muscles. The sciatic nerve was now raised upon a glass tube, and it was found that it could not be excited by the strongest galvanism. The neurility or special life of the nervous system was in fact gone; *while the peculiar life of muscular structure, viz. its irritability, had become preternaturally exalted.*

Another frog having been etherized till incapable of exhibiting any reflex phenomena (that is to say, until the nervous system was temporarily extinguished), the muscular system was still, under these conditions, highly sensitive to galvanism. The frog did not recover from the etherization. It was allowed to remain all night; and its muscles were still found susceptible to galvanism in a high degree, *but not to other modes of stimulation.* The nervous matter of the cord was now broken down and removed, and the body placed in a little water to prevent desiccation. It was again left all night; and on the following morning the muscles were found to be *exceedingly susceptible to slight blows or pinchings including not only the skin but also a small portion of muscular substance. These motions simulated in their extent and power volitional movements. They were excited with the utmost ease, and seemed to ordinary observers to be purposive acts resulting from sensation.* These effects were observed 36 hours after the etherization of the creature.

May 18, 1863.—A frog having died in spawning, the muscles were found to be somewhat susceptible to slight blows, and very susceptible to galvanism. A portion of the calvarium was removed so as to allow the brain and cord to be tested. A copper wire was thrust into the canal, and an attempt made to galvanize the cord, but with no result; neither did any contraction take place during the final destruction of the cord. In fact, the nerve-tissue was dead and could not be stimulated. This frog being left in this condition for 15 hours, the muscles of the thigh of one limb were found to be peculiarly susceptible to the influence of both slight blows and galvanism; and when a contraction was excited, the *limb was forcibly raised or drawn up, and remained so for several seconds.* After a few minutes' experimentation, in which many contractions were produced, *the force appeared to be exhausted*; hence it seemed that the force which confers contractility *had accumulated to a certain pitch or intensity, and was used up in the act of contraction.* The following is a more recent observation, from my experiment-book. 9 A.M. August 13, 1866. "On taking up this frog, *now dead*, and touching the limb, with my finger, which during life had been paralyzed by section of its nerve, *it was suddenly shot out as if alive.* I placed the body down, and one or two *apparently spontaneous movements* of small extent afterwards occurred. On touching the skin gently with the point of a needle, by the slight pressure upon the muscle beneath, movements of the limb were also induced; *but this high degree of exaltation very rapidly disappeared,* after which the muscles were

found ordinarily sensitive to galvanism." It is necessary to state that the limb exhibiting these effects had been paralyzed, so far as nervous influence is concerned, for 63 hours, and deprived of blood for at least 6.

We have here, then, three examples in which this phenomenon has been produced artificially, and one in which it occurred naturally. In all of them the *leading feature is, that the nervous and vascular functions ceased to exist long prior to the production of the exalted state of the muscular system*—in one case 13, in another 15, and in a third 36 hours; and in the last example nervous influence had been absent for 63 hours, and blood for 6 hours. We must not hastily infer from these experiments that it is simply necessary to destroy these functions in order to secure this hyper-irritable condition of the muscular system.

It is needless to say that cold-bloods may be destroyed in numerous ways which altogether prevent the exhibition of this peculiarity. Thus, if the head be crushed, the condition of the nervous system, which arrests suddenly the action of the heart, appears also to impair the powers of the general system of muscles, and causes rigor to supervene at a comparatively early period.

Again, in death by strychnia the irritability of the muscles is diminished and they pass quickly into the state of rigor, the flexors of the hind limb prior to the extensors.

In death by $CO^2$ the irritability is depressed and rigor comes on quickly.

Muscles subjected to chlorine lose their irritability very quickly indeed, and the state of rigor follows more rapidly than in any of the other cases.

Prolonged action of weak ether vapour removes every trace of irritability, and paves the way to early rigor.

Again, if after the section of the spinal cord at the junction of the atlas and occiput the creature can still control his limbs (as frequently happens with frogs), the post mortem exaltation of the muscles will be much less likely to occur than if the section was lower down, so as to completely paralyze them*.

* In the existing condition of neural physiology it may perhaps be desirable to offer some explanation of the above remarks. To those who are practically engaged in physiological experiment, it must be apparent that our present views of the functions of the cerebro-spinal system await considerable modification, if not reconstruction. Certain it is that to deprive *some* vertebrates of their *entire cerebral organs* is by no means to destroy their capacity for willing and feeling. To Mr. G. H. Lewes belongs the credit of having first prominently brought forward this highly important fact, in an admirable and logical essay on the nervous system, to be found in his second volume of 'The Physiology of Common Life.' Since perusing this essay I have repeatedly made experiments upon the matter, both in private and publicly before my class and colleagues, with the most unequivocal results. The matter is so important that I may be pardoned the insertion of an illustrative experiment. On March 30, 1863, 9.50 A.M., I struck off, with a sharp chisel, the head of a frog. At 10 o'clock the creature *spontaneously* drew up its extended limbs into the normal flexed position beneath its body, and then *moved itself* round in a circular manner three or four times. It then remained quite still for five minutes, and then again turned round a fourth of a circle after the fashion of the unmutilated animal. At 10.8 made another turn, and afterwards commenced to *move freely about the table as if very little had happened*. "10.40. This frog has executed several *spontaneous* leaps. At 11.45 I found it still crawling about. If in leaping it came down on its back, which it seemed liable to do, by struggling it soon righted itself. 1.20. This frog is even more vigorous and leaps and moves about more freely than before." I now cut off the upper portion of the spinal column and included cord, the frog was tremulously convulsed, but after a short time drew up its limbs, and *moved again spontaneously*. The removal of the last portion put a stop to the action of the larynx. Of such experiments as these I possess numerous records; but the above is sufficient for our purpose. It will occur to the reader that Marshall Hall laid particular stress upon what he deemed to be a cardinal fact in neural physiology, viz. *that no spontaneous movements ever occurred in decapitated animals*. On the truth of this observation he based

The general deduction warranted by the experiments seems to be, that any mode of death which tends to interfere with the processes generating muscular force, either by acting directly on the muscular tissue or indirectly by exciting the nervous tissue to the consumption of muscular force, is opposed to the production of this exalted state; on the other hand, modes of death which quietly destroy the nervous system by sedation or by withholding its nutrition (blood), and at the same time do not interfere materially with the muscular system, seem favourable to its production.

The extensive character of the contraction which takes place during this exalted state of muscular tissue appears to result from a propagative action: *e. g.*, in the most sensitive state it is simply necessary to include the smallest portion of a muscle within a pair of forceps, or to touch a single spot with the point of a fine needle, to excite contraction in a considerable portion of the muscular mass. As in the case of the heart, a few fasciculi immediately subjected to stimulation contract, and in the act excite contraction in contiguous fasciculi; and in this way the effect rapidly spreads throughout the muscle, and, by calling into play a large number of elements, induces a marked and continuous contraction allied to that produced by the medium of the nerves.

The nervous stimulus seems to differ from other modes of stimulation in the effect produced, mainly in the fact that it can call at once into effective action considerable masses of muscular structure by virtue of the minute distribution of its filaments among the muscular elements. In the case before us a similar effect seems to be brought about by a preternatural degree of excitability on the part of the muscular tissue itself.

In dealing with my second proposition, it is not my intention to recapitulate the many arguments which have been adduced to show the independence of muscular irritability of nerve-force. I wish simply to demonstrate that in all cases where nerve-influence may be considered in active operation there is a diminution of muscular irritability, and that, conversely, when that influence is cut off from muscle, there is a tendency in the muscular force to accumulate. In all animals there is a marked distinction in the states of the nervous and muscular systems during mental activity, and the condition

his theory of reflex or excito-motory action. The arguments of Dr. Hall may be briefly summed up thus:—If cold-blooded animals or the young of warm-bloods be decapitated, or their brains removed, irritants applied to their bodies will still induce movements. That the animals have lost the power of volition is maintained on the ground *that they perform no spontaneous movements*; and inasmuch as volition is the *second link* in the chain of which sensation is the *first* and motion the *last*, the creatures cannot possess sensibility; therefore the movements which follow irritation, however purposive or adapted to ends they may seem, are not the result of either sensation or volition, inasmuch as these are properties of the brain alone; therefore they result from a purely mechanical arrangement, the principle of the operation of which is that any excitation applied to the extremities of sensory nerves is conveyed to the nervous centre and there reflected on to a motor nerve, which in its turn stimulates muscle into action, *no sensation whatever being perceived*. In respect to these opinions of Dr. Hall, I would remark that, whether or no the absence of spontaneous movement proves the absence of volition, it is quite certain that the converse is true, viz. that the presence of spontaneous movement proves the existence of volition; and, as seen in the above experiment, the decapitated trunk gives all the evidence *we can have or ever do have* of the possession of both volition and sensation: the whole theory of Marshall Hall is completely disproved and subverted, and the brain can no longer be regarded as the exclusive seat of these powers. In order to secure success in this experiment, certain precautions are necessary. 1. No anæsthetic should be used, as it materially decreases the chance of recovery. 2. The hemorrhage must be trifling. 3. The nervous tissue must be cut, not crushed. To achieve these conditions, the angles of the mouth should be slit sufficiently far back to allow of the removal of the head by means of a sharp chisel; the lower jaw, tongue, and principal vessels are then uninterfered with.

in which volition is cut off from its nervous associations. By the state of mental activity, I mean simply the waking state of an animal, in contradistinction to the condition which obtains during profound sleep, fainting, or complete etherization.

During the waking state the muscular system of an animal is maintained, through the medium of the nervous, in a condition of slight contraction, in which the muscles firmly balance or steady each other, and thus the will holds firm possession of the muscular organism. It would appear that this active volitional state involves a constant expenditure of neuro-muscular force. In profound sleep and allied conditions this psycho-neural influence ceases to operate upon the muscular system; hence we find the head falls forward upon the chest, the arms sink down, the fingers relax; if the person is standing he may fall down, or if sitting slide from his chair; the eyes become closed, &c.

In fainting and death the same powerless, flaccid condition of the muscular system is seen in excess; yet in all these cases the elasticity and irritability of the muscular system still exist.

Sleep, fainting, deep etherization, and death seem to represent different degrees of what may be called functional neural paralysis, in contradistinction to purely muscular, in which the irritability of the muscular tissue is diminished or gone, while the neurility of the nervous centres and nerves remains.

When we reflect that the mere waking state of animals involves a constant expenditure of both nervous and muscular force, the importance of sleep for their reaccumulation becomes obvious. It is not, therefore, alone in the production of motion that the will consumes neuro-muscular force, but also in the maintenance of the normal position of the animal; for few muscles of the body are during the waking state in a condition of non-control or laxity; most are subjected to continuous stimulation of a mild form. In the tremulousness of old age, or after exhausting disease, we witness the effect of deficiency of this tonic power.

Whenever the mind has to make a greater effort than usual for the accomplishment of an act, it is an evidence that the forces of the system are below par, and do not respond with their accustomed delicacy to the influence or stimulus of the will; in such cases the animal is said in common parlance to be tired or fatigued.

The degree of stimulation exercised by nerve upon muscle may be normal or abnormal; and in proportion to the severity of the stimulation will be the rapidity with which irritability will be consumed and rigor mortis supervene.

There appear to be three conditions of nerve in respect to the muscular tissue:—

1. It may exist as a mere structure, *i. e.* functionally inactive.

2. It may be in that condition which enables an animal so to control its limbs as to maintain any required position.

3. It may be concerned in producing actual movement.

The two latter conditions appear to be degrees of the same kind of action.

We wish to ascertain by direct experiment whether all or any of these conditions of nerve are concerned in exhausting muscular irritability.

This is by no means an easy matter; for although we have abundance of experimental evidence from the negative stand-point, that irritability is *exalted*, in the *absence* of nerve-influence, it is difficult to devise reliable experiments in support of the positive proposition. The reasons of this will become

more obvious as we proceed to review the interesting experiments which clear the ground. It will be well to bear in mind the conditions necessary to a successful experiment, as the bearing of the after remarks will be more apparent.

1. The source of irritability, viz. the blood, must be cut off from two symmetrical limbs of the same animal.

2. The possibility of nervous supply must be cut off in one limb and retained in the other.

Three animals (in all respects similar) so situated must be taken.

One must be placed under conditions which enable the limb with the nerve intact to remain in a flaccid, uncontrolled state, equivalent to the condition of volitional paralysis; another must be caused to maintain continuous control over the limb, without the induction of motor acts; the third to exercise the limb and contract the muscles.

These conditions being achieved, we have to note in which of these cases rigor mortis of the limb supplied with nerve sets in earlier than in the other limb deprived of both nerve and blood. This will furnish us with the comparative *rate* at which the irritability is exhausted in limbs so situated.

The next question is, whether such an experimental combination is possible.

At the very threshold an insurmountable obstacle meets us in the case of warm-blooded animals; for in them to cut off the supply of blood is to induce immediate paralysis, which is rapidly succeeded by the condition of rigor mortis. This is well illustrated in the effect of deligation of the abdominal aorta. During the early stages of the paralysis thus induced in the hind extremities, both the nerves and muscles are susceptible to the stimulus of galvanism, and sensation is likewise perfect. Why, therefore, is it that volition is unable to influence these limbs? The same, and similar experiments upon cold-bloods enable me to answer this question. I find that if, in these creatures, the circulation be cut off from a limb in which the nerve is still allowed to remain, *the paralysis is not immediate—in fact, does not come on for a period of from one to three hours*, the frog during this interval being able to use the limb; but at length we get the same condition of complete paralysis which obtains at once in the warm-bloods. The following experiment will illustrate this:—

August 11, 6 P.M. 1866.—A large frog was taken and thoroughly etherized. The artery supplying one of the hind limbs was taken up and tied, and then cut below the ligature. The ligature was applied to prevent general bleeding. The nerve was then raised up out of the way, and the whole of the structures of the thigh were cut through to the bone, leaving the nerve intact. The skin was then brought together with sutures. In rather over an hour the frog began to respire, and I found he possessed sensibility in the limb, and was also able to move it a little. 10 P.M. The frog seemed to have complete control over the partially amputated limb in all those muscles still possessing bony connexions. 8 A.M. Aug. 12. The limb was found to be completely paralyzed, but quite flaccid. It possessed very little irritability—quite a marked difference in this respect between the two limbs. The limb is now dragged after the body at full length. *Its sensation appears perfect.* 4 P.M. *The paralyzed limb is now void of all irritability*, as tested by galvanism. It *is, however, still flaccid, and the sensibility to pain normal.* 9 A.M. Aug. 13. The paralyzed limb is now in *a state of rigor*, and *there is an entire absence of sensation.*

In this case, as in others of the kind, we observe there is a gradual dimi-

nution of muscular irritability. But this will not account for the paralysis for we have many examples in which frogs would move their limbs by volitional effort, where the muscles are far less irritable, and rapidly passing into a rigid state; such examples are furnished by certain stages of thermal tetanus. The following experiment will throw light upon the real causes of the paralysis.

August 10, 4 P.M. Compression was exercised upon the abdominal aorta of a frog. It was then ascertained by the microscope that the circulation in the limbs was completely arrested. The sciatic nerve of one limb was then divided. The paralysis of this limb was complete. *The creature had perfect control over the limb deprived of blood, but with the nerve intact.* In about an hour afterwards it was observed that, although quite vigorous, it *had lost all control over this limb.* I tested the muscles of both limbs for irritability, and found them in both cases tolerably sensitive. The distal extremity of the cut nerve is also irritable. 10 P.M. The limb possessing its nerve remains perfectly paralyzed, and is, with the other limb, dragged after the frog at full length. The tourniquet was now removed from the aorta, and the creature placed in water. At this time the muscular irritability was at a very low ebb. At 8 A.M. Aug. 11, the frog was much in the same condition; the limb in possession of its nerve and artery was still completely paralyzed, although the muscles of both limbs had acquired increased susceptibility to galvanism. On examining the webs, I found a free circulation now going on in both limbs. The sensation in the skin of the paralyzed limb possessing the nerve is perfect. 1 P.M. No return of motor power in the anatomically perfect limb. 9 A.M. Aug. 12. The limb is still paralyzed, but the muscles are *very irritable, in fact, more than normally so.* At 8 A.M. Aug. 13, the frog was placed under the influence of strychnia, to ascertain if the nervous impulses generated by the drug would pass over the nervous obstruction and contract the highly irritable muscles. Not the slightest effect, however, was produced.

This experiment shows that in thus cutting off blood from a limb we interfere seriously with the functions of the motor nerve; and as in animals deprived of blood the excitability of nerve-tissue is always first to perish, it is legitimate to assume that this degradation of the nerve is the primary effect of cutting off the blood from a limb, and therefore the cause of the paralysis. This functional degradation of the nerve being brought about immediately in warm-bloods and gradually in cold bloods, is consistent with all our knowledge of the differing degrees of vital persistence possessed by these classes respectively. This experiment further proves that the nerve may suffer past restoration by prolonged absence of blood, but that the muscular irritability may be completely restored—in fact, exalted.

The question as to the part of the motor nerve (the trunk or the terminal branches) concerned in the paralysis is one of extreme interest. Inasmuch as the sensory fibres still convey their impressions, it seems probable that the defect in the nerve must lie in its ultimate distributions to the muscular tissue; otherwise we should have to consider that the motor fibres of the trunk of a nerve are dependent upon the general circulation of a limb for their integrity, and that the nutrition of the sensory fibres of the same trunk is maintained in some other way. There seems to be a remarkably interesting analogy between this form of paralysis and that induced by the action of the woorara poison*.

* How is it that the terminations of the motor nerves in muscles are so interfered with, while neither the trunk or its ramifications, nor the muscular tissue, appears to be affected

Comprehending now more fully the nature of the paralysis which results from depriving limbs of blood, we are in a position to see that whatever influence nerve may exercise in exhausting irritability, when the source of its replenishment is cut off, must *necessarily be exercised prior to the accession of the paralysis*; for this form of paralysis affecting the ultimate distributions may be regarded as equivalent to the absence of nerve-tissue; and under such circumstances the irritable muscular tissue represents the condition and capacity of living muscle freed from nerve-influence.

It is clear, then, as the terminal distributions of the nerves to the muscles of warm-bloods *become at once insensible to the stimulus of volition*, that the nerve in these cases can have no influence in hastening rigor by exhausting irritability, and the accession of rigor mortis here must therefore be referred *entirely to absence of the blood*; for in these cases we are not even disturbed by speculations as to the possible influence exercised upon the muscle by the *mere presence* of living nerve-tissue in a state of inaction.

We see, then, that the question with which we started is one capable of solution only by experiments upon cold-bloods carried out in the manner previously indicated; *for in these only is it possible for nervous influence to act upon muscular irritability in the absence of the blood*, and in these for a limited period only, but, nevertheless, sufficiently long to prove whether or not the *mere presence of inactive living nerve* diminishes muscular irritability, or whether the loss of irritability is appreciable only when the muscle is either *controlled or induced to contract* by nervous influence. Space will not permit me to recite the complicated experiments by which the necessary conditions were achieved, and I must content myself in this place by briefly stating the deductions arrived at.

1. Mere presence of living nerve in a state of inaction neither hastens nor retards the accession of rigor, and therefore has no influence on irritability.

2. The condition of nerve concerned in simple muscular control and in contraction leads to earlier rigor mortis, and therefore possesses the power of exhausting irritability.

Leaving now this aspect of the question, we proceed to inquire what evidence do we possess that muscular irritability is capable of abnormal exaltation in the absence of nerve, or in those uncontrolled powerless states of the muscular system which, from the absence of volitional impulse, are equivalent thereto.

First, we have the fact that if one limb of a frog be paralyzed by section of its nerve, *after a certain period has elapsed* it will be found more susceptible to the various forms of external stimulation than the other limb; and if such an animal be killed or happen to die, the limb in which the nerve is intact will lose its irritability, and pass into the state of rigor, long prior to the limb the nerve of which has been divided.

Dr. Radcliffe remarks, "Many experiments might be mentioned, all of which seem to show more or less clearly that the disposition to convulsive muscular contraction is inversely related to the supply of nervous influence to the muscles." *Vide* 'Lancet,' 1863, vol. i. p. 321. This is in the main correct, but it renders no support to the inhibitory theory of nervous action as propounded by its talented author. *The readiness with which muscle contracts is always in direct proportion to the amount of force accumulated in its structure, or, in other words, to its irritability.* It is not that the absence of nerve

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past restoration? Is there any intermediate tissue differing from nerve or muscle which forms the bond of union between them?

produces a greater proclivity to contraction in the muscle, but that the muscle in the absence of nerve can accumulate the force on which irritability depends. In all the experiments in which muscle contracts more readily in the absence of nerve, the element *time* is an important ingredient; for if its influence be excluded, the opposite condition, viz. *that muscle contracts more readily in the presence of nerve-influence, is the normal law*, as I hope shortly to show.

To the fact that muscle relieved from nerve-influence acquires additional contractile energy I add the further important observation, that it retains its irritability not unfrequently for days after its fellow has passed into the state of rigor mortis.

The experiment just cited also tends to show that the presence of nerve in action keeps down muscular irritability and initiates rigor mortis, as before demonstrated; for we see that when blood is circulating equally through two limbs, the irritability of the one cannot be maintained at the same standard in the presence of the nerve. If rigor mortis could be regarded as a contraction, it might be supposed, in accordance with old notions, that the dying nervous system had something to do with its premature induction; but as rigor is a mere setting of the muscular tissue, this idea has not a shadow of probability*; besides the rigor will supervene in the limbs simultaneously in cases in which the death of the animal succeeds immediately the section of the nerve.

Dr. Brown Sequard has furnished us with a most beautiful experiment which bears intimately upon the present question, and which also has been used by Dr. Radcliffe to support the proposition, "that the state of muscular relaxation is more readily disturbed by contraction, and that the contraction itself is more powerful when the muscles are receiving a diminished supply of nervous influence." The experiment is as follows:—Two frogs (A and B) are taken and their spinal cords divided low down in the cervical region so as to remove the lower limbs from the control of the brain and medulla oblongata. In such cases the reflex (?) contractions induced by pinching the toes are capable of raising heavier weights than could be raised by the hind limbs when the frogs were in their normal condition. Thus they raised *before* division of the cord 60 grammes. Immediately *after* division A raised 20 and B 10 grammes only. In five minutes A raised 45 grammes and B only 30; thus they proceed increasing rapidly in power, till in four hours A can sustain 140 grammes and B 130. At the end of twenty-four hours they are found to have reached their maximum point, viz. 150 and 140 grammes respectively.

The first point worthy of notice in this important experiment is, that a degree of shock was produced by the operation in frog A measured by a loss of power equivalent to 40 grammes, and in frog B to 50 grammes. This diminished power would be entirely due to loss of nervous force and muscular irritability, chiefly the former,—partly the direct result of severe injury to the nervous centres, and partly of loss of blood and depression of the heart's action.

Secondly, it would be at this period, when A could raise but 20 and B 10 grammes only while suffering from shock, that the *nervous influence would be at its lowest ebb*; and if the muscles possessed a fair amount of irritability (which they certainly do) after such operations, this should be, if Dr. Radcliffe's views are correct, *the period at which the greatest weights could be raised*; for the period of profoundest nervous shock admitting of neural excitement of the muscles would be the one in which the minimum degree of nervous influence exists.

* See my paper on that subject in Brit. Assoc. Report for 1865, Trans. of Sect. p. 109.

But it is evident that the muscular and nervous systems progressively acquire force from this shock-point, stopping not at their normal amount, but reaching a marvellously abnormal degree of exaltation, and this under the very conditions I have pointed out as leading to nervous and muscular exaltation, viz. the absence of the exhausting principle of volition or nerve in action.

We see, then, by these experiments that muscles possess no abnormal powers *immediately after* they are liberated from nerve-influence, as in section of the sciatic, or after they are removed from the influence of the upper part of the cord, but that these *are gradually acquired*, many hours being consumed in reaching the maximum degree. The correct explanation, therefore, of Sequard's experiment would seem to be, not that muscle contracts more readily in the absence of nervous influence, but that, in the absence of volitional or other excitement, both the nervous and muscular systems can accumulate their own special forces, and that to an extent that can never become apparent under normal life conditions. Thus, in the experiment, 60 grammes measure the nervo-muscular force of the frogs when unmutilated. After the operation the frog B suffers more from shock, and the sum of its nervo-muscular force is represented in consequence by just half that of the other, or one-sixth of its normal force; A possesses after the operation one-third of its normal force. The nervous system gradually recovers from the influence of shock, but is no longer stimulated by volition, and therefore no longer controls the muscles in the usual way; consequently they remain flaccid or paralyzed, and this gives them an opportunity of accumulating force, which they gradually do till they acquire nearly three times their normal amount. The exact proportions in which this accumulated force is divided between the nervous and muscular systems is a delicate subject for future consideration.

The fact is here broadly stated, that the psychical principle of volition dominates and exhausts both the nervous and muscular systems, and that in the absence of this influence they acquire exalted powers*.

I propose now to turn for a short time to a consideration of the part which the blood plays in connexion with muscular contraction. The following is the proposition which I shall endeavour to maintain:—

That the blood or nutritional plasma derived therefrom not only furnishes the materials by which muscular contractility is maintained, but is likewise the determining cause of that polar arrangement of the muscular molecules which maintains or restores the elongated or relaxed state.

* In June 1866, Professor Frankland read a paper to the Royal Institution of Great Britain "On the Source of Muscular Force," which contains the following passage:—"The combustible food and oxygen coexist in the blood which courses through the muscle; *but when the muscle is at rest there is no chemical action between them.* A command is sent from the brain to the muscle, *the nervous agent determines oxidation.* The potential energy becomes active energy, one portion assuming the form of motion, another appearing as heat. *Here is the source of animal heat, here the origin of muscular power.* Like the piston and cylinder of a steam-engine, the muscle itself is only a machine for the *transformation of heat into motion.*" The reader will at once perceive that this idea of muscular force being *generated only during nervous action* is quite incompatible with the experiments and views of the author of this paper. There can be no doubt that chemical action is constantly taking place between certain elements of muscle and blood, and *that force is being continuously stored*, nervous action being concerned in its consumption, and discharge rather than its formation. As to heat, it is certainly generated in other portions of the body besides the muscular structures; and if *nervous action* is necessary to oxidation, how is this heat produced?

The piston and cylinder are a means of regulating mere repellent force; but muscle is a mechanism having the power to convert some fluid, which is either electricity or a close correlate, into a source of both repellent and attractive power; for it is only by assuming two such forces that the phenomena of elongation and contraction can be explained.

Last year, when treating upon the question of rigor mortis, I drew the attention of the Section to a form of muscular contraction induced in cold-bloods by the irritant action of such vapours as ether, chloroform, bisulphuret of carbon, amylene, &c. I pointed out that they were the most extreme forms of contraction of which these muscles were capable. The persistent, in most cases permanent character of the contraction at once associated it with the forms of tetanus induced by water of certain temperatures and by the discharge from Ruhmkorff's coil. The extreme delicacy of this mode of exciting muscular contraction by ethereal vapours has enabled me to perform some very interesting and instructive experiments.

I have succeeded in proving, by experiments in which the nervous system has, as far as possible, been removed, and, better still, by experiments on isolated muscles, (1) that both chloroform and warm water act *directly upon* and *produce universal contraction of the muscular tissue, which, according to the circumstances* of its *induction, may or may not be permanent*; (2) that when the nervous and vascular systems are present they complicate the result, and furnish us with illustrations of most important physiological principles.

Taking first THERMAL TETANUS, I find two normal limbs (*i. e.* supplied with both blood and nerve-influence) contract simultaneously. Two limbs deprived of both blood and nerve-influence also contract simultaneously. Of two limbs, the one having neither nerve nor blood, and the other both nerve and blood, the latter contracts first. Of two limbs, the one having neither nerve nor blood, and the other blood only, the former contracts first.

In CHLOROFORM TETANUS the same holds good as in the first two examples of thermal tetanus; but of two limbs, the one having neither blood nor nerve, and the other having both blood and nerve, the former contracts first. Of two limbs, the one having neither blood nor nerve, and the other nerve but no blood, the latter contracts first.

An analysis of these various results shows that both warm water and chloroform exercise an excitant action upon the nervous system of the frog, which tends in both cases in the direction of muscular contraction, but which of itself alone is too weak to bring about such an affection of muscle, and, further, that the warm water is more powerful in this respect than the chloroform. It also affords evidence of the important principle, that certain elements of the blood in the interstices of the muscular tissue oppose a powerful obstacle to such agencies as tend to throw muscular tissue into a state of contraction.

Muscle when dynamically perfect is related, on the one hand, to certain stimuli, as nerve and external agents, which tend to induce contraction, and, on the other, to some of the elements of blood, which bring about its elongation; but its degree of proneness to fall into contraction appears to be directly proportionate to the amount of force generated in it by the blood—in other words, to its irritability; and although the galvanometric evidences of the existence of force are *masked* during contraction by the derived electromotor currents taking on the negative variation, yet this by no means proves (as some suppose) that the *blood-generated forces* are absent; for we have previously seen in explaining Sequard's experiment that the contractive energy, *i. e.* the tendency of the molecules of muscles to approach each other, may be increased two-and-a-half times, which is at once proof that they do not approach by virtue of any *permanent force* which they possess as mere physical atoms; for such force would be a fixed and not a varying quantity. It is evident therefore that both the power of contraction and of elongation is derived from the blood, and not the elongating force alone; and we must

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not, with Dr. Radcliffe, fall into the error of considering that muscle necessarily passes into a state of contraction in the absence of an elongating force; for experiment shows that the most perfectly relaxed state of muscle is compatible with the absence of every trace of irritability.

I shall now proceed to narrate several experiments in which the relation which blood bears to muscular tissue is more fully displayed, and by which it is made evident that the blood gives the power by which the elongated or relaxed state of muscle is maintained.

Exp. 1.—A frog is moderately chloroformed; when removed from the vapour, particular note is made that the limbs are perfectly flaccid or relaxed, and that the heart is beating. The heart is now exposed and excised, and in a few seconds or minutes, according to the amount of chloroform imbibed by the tissues, *the limbs will spontaneously extend and become rigidly tetanic.*

Another frog was slightly chloroformed, and the observation made that the heart was still acting, and that the whole of the muscles were quite flaccid. The structures of one thigh were then cut through to the bone, so as to sever all nervous and vascular connexions. The muscles of this limb gradually commenced to contract, and in a few minutes the leg and foot were extended and the webs stretched out. The muscles of the other limb and the trunk generally remained in a completely relaxed state. After the lapse of some minutes I observed a tendency in the unmutilated limb to extend, and in the fore feet to approach the central line of the body, and to clasp, as in tetanus of the male frog. Directing my attention to the heart, I could not detect any pulsation, and I therefore removed the parietes of the chest; the access of air reexcited the action of the heart, and very quickly the muscles of the unmutilated limb and general trunk became again flaccid. The heart again losing power, the condition of contraction a second time came on, and gradually became more and more complete. On reexamining this frog after the lapse of an hour, I found that the muscles had again become flaccid—this time not only in the unmutilated limb, fore feet, and muscles of the trunk, but also in the limb which, as far as its soft parts were concerned, was completely amputated. Not the slightest trace of irritability, however, was now detectable. Nothing could be plainer than the teaching of this experiment. The muscular tissue was subjected to a dual influence:—first, the chloroform tending to excite it to contract; secondly, the blood, or certain of its elements, tending to maintain it in the relaxed or elongated state; and accordingly as one or other of these influences prevailed, the muscles became alternately contracted or relaxed. After the cessation of the circulation the antagonism was feebly continued between the evaporating traces of the chloroform on the one hand, and the interstitial juices of the muscle on the other, the balance of power being so nicely adjusted that the interstitial nutrition was just capable of restoring the relaxed condition, but incapable of conferring the slightest degree of irritability upon the muscles. It is rarely that we obtain this exact balance of the influences; for if the amount of chloroform in the muscles is too large, the condition of permanent contraction obtains; and if too small, there are slight evidences of returning irritability after the muscle has become elongated.

Another satisfactory mode of exhibiting this function of the blood is to compress the abdominal aorta of a frog, and, having ascertained by the microscope that the circulation in the lower limbs is securely arrested, oil all parts of the body, with the exception of one limb, expose this to the vapour of chloroform, protecting as much as possible all other portions of the body from its influence. This limb will after a time show a disposition to con-

tract. It should then be removed from the vapour; and when it has become fully extended, the tourniquet should be taken off; the blood will then gradually find its way into the limb, and restore the flaccid elongated condition.

In this experiment we have the contrast of two limbs without blood, one of which is under a contracting influence; and we get an excess of chloroform in the tissues of one limb and protect the animal to a great extent from being generally affected. As might be expected, this state of contraction is never so easy to produce when an animal possesses its full complement of blood; for although the blood may be stagnant in the vessels, it will supply for a considerable time the elements which oppose the contracting-powers of the chloroform; hence, if we would produce the state of contraction under such conditions, an amount of chloroform is demanded in the tissues which ordinarily destroys the animal. But by adopting the plan of allowing the ingress of the chloroform only through the limb which we wish to affect, we overcome this obstacle and retain the heart in such a condition that the circulation can be restored and the contractive state dissipated when the mechanical impediment is removed from the aorta.

In concluding this paper, I propose to take a hasty survey of the various affections of muscular tissue as they have presented themselves in my experiments.

Let us take as an illustration the gastrocnemius muscle of the frog in the elongated or uncontracted state. 1. It may exist in this elongated or uncontracted state with all its dynamical powers in a state of integrity. This is its normal condition, as we see it in the absence of stimuli. 2. It may exist in this state when deprived of dynamical power, or, in other words, in the absence of irritability. 3. Both these conditions of elongation may be associated with softness or flaccidity of the muscular structure,—the former necessarily so; the latter not, as the fixity of rigor may prevail.

Now let us take the same muscle in a state of complete contraction. 1. It may exist in this state of contraction with its dynamical powers perfect. This is true in those normal contractions which quickly give place to relaxation. 2. It may exist in this state when deprived of dynamical power, as seen in the forms of permanent contraction induced by warm water and ethereal vapours. 3. In a state of softness, or in a hard coagulated state. The soft state is represented by normally contracted muscle, severed from one of its attachments. The hard state is induced by ethereal vapours and extremes of temperature.

As with the state of elongation, so with that of contraction, the truly dynamical state is one of softness.

The dynamical conditions on which irritability depends may therefore exist both in the elongated and in the contracted state, and may also be non-existent in both of these states. Properly speaking, irritability is no more the tendency which a muscle exhibits to contract than the disposition it shows to relax or elongate subsequently to contraction; in fact a comprehensive definition must include both these conditions. Nor is either of these states to be regarded (as far as muscle alone is concerned) as conditions of rest; for they are both active states so long as the muscle is a vital structure, and both inactive when the dynamical power of muscle are absent.

As yet there seems to be no reliable experimental evidence to show that muscle *per se* ever contracts spontaneously, *i. e.* in the absence of a stimulus; but there are plenty of indications that the same agent is a greater stimulus at one time than another; nor is there any evidence to show that muscle

will contract on the withdrawal of elongating influences, but abundance to the contrary in the fact that it will remain in the elongated state in the absence of all susceptibility. Contraction and elongation would seem both to be dependent on the existence of polar forces, which have a certain relation, on the one hand, to excited nerve and external stimuli, and, on the other, to some of the elements of the blood,—excited nerve and external stimuli inducing the attractive, which involves contraction, and the blood the repulsive polar attitude essential to elongation.

The attractive state of the muscular molecules which represents contraction, is the condition in which force is exhausted by the association of unlike polarities; while the state of elongation being that in which every molecule is opposed to every other, force may be accumulated. In proportion to the amount of force accumulated in the molecules will be the intensity of their contractive or elongative energy; and also in proportion to their charge will be their proclivity to disturbance—in other words, their susceptibility to stimuli.

When a stimulus can no longer act, it is because the force is exhausted. If the chemistry of the muscle be not absolutely arrested, the power to contract under a stimulus will return. If at the moment of its action a stimulus be so excessive as to induce the attractive state of the molecules, and at the same time to destroy the force-producing powers of the muscle, the molecules will remain in the state of approximation, simply because there is an absence of any power to rearrange them. Conversely, if the force-producing powers be destroyed during the state of elongation, the molecules remain apart.

Muscle, therefore, as a *dead structure*, has no tendency to remain in either one or other of these states preferentially. The loss of irritability is the first evidence we possess of a series of chemical changes which culminate in such a coagulation of the muscular juices as to cause fixity, or setting of the muscle. When these changes take place in the elongated muscle, the fixed condition is produced which we recognize as rigor mortis; when, on the other hand, they take place in the contracted muscle, they induce the fixed hard condition of the muscular structure seen in ethereal and thermal contractions.

Substances which affect muscular tissue may be classified as pure stimulants, stimulo-coagulants, and depresso-coagulants. All substances possessing the coagulant property arrest the chemical reactions between the muscular tissue and the blood, by which the fluid on which irritability depends is generated. The stimulo-coagulant class is represented by the irritant action of chloroform and the ethers generally, and by extremes of temperature; the depresso-coagulant by chlorine, carbonic acid gas, and the sedative action of very dilute ether-vapour.

*It is possible, therefore, to have rigor mortis, or coagulative setting, in both elongated and contracted muscles.*

While, therefore, my researches contradict the theory which refers the phenomena of living muscle to statical electricity *as an elongating power simply*, contraction being regarded as due to an inherent attractive power of the muscular molecules, they are singularly in accordance with the conclusions of Du Bois Reymond, who regards every elemental part of muscle as a centre of electromotor action, containing within itself positive and negative elements, arranged in a dipolar series,—and seem to fill up a gap, by showing that the *repulsive attitude* of this series is *maintained by the blood.*

## *Report on the Physiological Action of certain Compounds of Amyl and Ethyl.* By BENJAMIN W. RICHARDSON, *M.A., M.D., F.R.S.*

IN two previous Reports to the Association, I dwelt especially on the action of certain of the compounds of amyl. The first Report dealt exclusively with the substance known as the nitrite of amyl. The second Report had further reference to the same body, and also to amylene, amylic alcohol, and the acetate and iodide of amyl. In some degree these Reports were complete as far as they went; that is to say, the facts presented were sufficient to demonstrate what visible physical influences were exerted on dead and on living matter by these representatives of the amyl series; and as I carefully separated the facts from the speculations that were fairly to be founded on them, the Association expressed its satisfaction by requesting me to continue researches in the same direction but with a wider object. I was desired in the next Report to repeat what might require repetition, but specially to pay attention to the *ethyl*-compounds, with a view to determine, if that were possible, whether there was any analogy in physiological action between the analogous compounds of the two series.

### SUMMARY OF PAST RESEARCHES.

Before I enter on new ground, it will be advisable for me to recall the main facts described in previous years and bearing on the amyl series.

1. It was shown that the *nitrite of amyl* when inhaled was the most powerful excitant of the circulation at the time known. It was demonstrated that during such inhalation the action of the heart was doubled in rapidity in thirty seconds, in men and warm-blooded animals: further, it was proved that this intense action was immediately followed by deep suffusion of the skin, by breathlessness like that produced by running, by a peculiar sensation of fulness and throbbing in the head, and ultimately by failure of muscular power of the extremest kind. It was also proved that there was no destruction of the nervous sensibility, that in animals there was an obvious expression of sensibility up to the moment of death. Lastly, it was shown that in cold-blooded animals, such as frogs, the nitrite of amyl suspended animation for hours, and even days,—and that, in young warm-blooded animals, after exposure to it until they seemed to be dead, the action of the heart continued for so long a period as eighteen hours.

2. In respect to *amylene*, it was shown that the vapour of it was antiseptic, even when freely admixed with air; physiologically tested on living animals, it is found to be capable of administration by being inhaled. It does not provoke local irritation, but it rapidly produces collapse and total insensibility to pain. At the same time it seems to interfere less with consciousness than other narcotic vapours. This fact is of peculiar interest, because the apparent consciousness exhibited by the subject is not shared in by himself, it is an objective, not a subjective phenomenon. The person under the influence of the vapour may perform acts which have all the semblance of conscious acts; but when he recovers he has no recollection of anything that has occurred. The state thus induced is very much like the phenomenon of somnambulism; and I ventured to suggest that in this experiment we had a key to the cause of the disease somnambulism, viz. that there was possibly formed in the body of the somnambulist, by a faulty digestion, a substance of similar action to an amyl-compound. Amylene I showed was a good anæsthetic, and many surgical operations have been performed under its in-

fluence, but it enters into no chemical combination with the tissues. This is due to its great insolubility in the blood and animal fluids. Amylene requires 9319 parts of water for its solution.

3. Of *amylic alcohol* it was shown that, like amylene, it was antiseptic. When the vapour of it is inhaled, it produces first irritation of the nostril, and next drowsiness and a kind of coma, but without insensibility to pain. In this comatose state there is developed a peculiar muscular action, a series of rigors which increase in force under any degree of excitement; but it is almost impossible to destroy life by its means. Animals brought to the verge of death and seeming past all recovery begin to rally so soon as they are placed in the open air.

4. The *acetate of amyl* was shown to produce the same kind of symptoms as those produced by amylic alcohol; it also preserves organic substances from putrefaction. It is used for flavouring-purposes under the name of essence of pears.

5. The action of the *iodide of amyl* was shown to be somewhat different from that of any of the other compounds. When inhaled it induces mixed symptoms, resembling in part those produced by the nitrite of amyl, and in part those produced by amylic alcohol. It causes excitement, great tremor of muscles, and during recovery a singular motion of the animal in a circle; it also excites salivation, and renders the extremities of the animal red and vascular during inhalation.

In the discussion which followed the reading of the papers named above, one special point attracted most attention. A question first was asked by Dr. Heaton, of Leeds, and afterwards by Professor Wanklyn:—Whether the differences of symptoms observed in dealing with different compounds of the amyl series turned actually on a change in the base itself, or on the combination of the base with a new compound. To take an illustration: was, for instance, the nitrite of amyl so peculiarly active simply because it was an amyl-compound, or because it was the *nitrite* of amyl?

This question is one of the chief (if not the chief) questions answered in the present Report. It was considered in the last Report in the following terms:—"The base amyl is, if I may use the expression, the keynote; but variations are introduced as new elements are added. The order of variation is most interesting. We take a simple hydrocarbon, the hydruret of amyl, and we have an almost negative body, acting not unlike nitrogen, and partly destroying motor force and consciousness, but no more. We introduce the element oxygen into the inquiry by using the hydrated oxide of amyl or the acetate, and there is added to the above-named phenomena violent and persistent tremor. We move from this to another compound, and bring iodine into the field, and the phenomena now embrace free elimination of fluid from the body, vascularity of the extreme parts, with increased action of the heart and of respiration. We change the combination once more to bring nitrogen and oxygen into operation with the base, and the vascular action is raised beyond what is seen from any other known substance, to be followed by a prostration so profound that the still living animal might for a time pass for dead."

## NEW RESEARCHES.

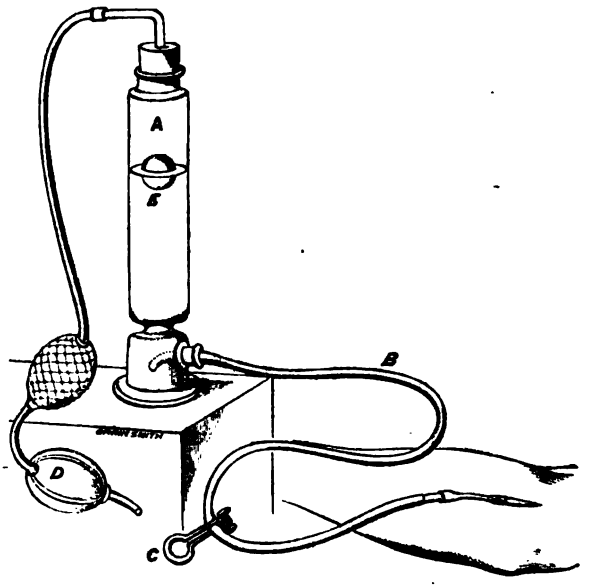
In the past year I have repeated the experiments conducted originally with the compounds of amyl, the compounds themselves being most accurately made. The result has been to confirm the facts previously observed, in all their integrity. In two directions I have extended these researches, with the

object of trying to make the substances under notice of practical utility to mankind.

### Nitrite of Amyl as a Remedy.

I first experimented to ascertain whether nitrite of amyl, which, as we have seen, exerts so decided an effect in quickening the action of the heart when it is inhaled by the living animal, might be turned to account as a means for stimulating the heart into action in cases where that organ has suddenly ceased to beat, as in cases of fatal fainting, in drowning, in sunstroke and lightning-stroke, in death by chloroform, and in suffocation from other narcotic vapours. To test this, the substance was introduced into the body in two ways—by artificial respiration, and by transfusion directly into the heart through the arteries. By neither of these methods could any decided effect be produced. By the first (the artificial respiration) a spasmodic action of the diaphragm and a peculiar action of the muscles of the nose are produced for a short time; but the effect is very transient. By the second, the effect seemed to be that the action of the heart was the more decidedly and rapidly paralyzed. In one case, in connexion with my friend Mr. Gay, after repeating in the dissecting-room the experiment of the injection of a dead limb of the human subject with oxygenated blood, I introduced a free current of a blood containing one minim of the nitrite of amyl to the eight ounces. The muscles were by this means evenly and steadily injected, and the odour of the amyl-compound was distinctly perceived; but there was no sign of muscular action in response to the injection, and muscles laid bare and subjected to irritation were still quiescent.

For these experiments I invented a new instrument for transfusion, which works so simply and effectually that I may be excused, perhaps, if I diverge for a moment to describe it: the practical physiologist will find it of great value in many inquiries. This instrument, as shown in the diagram, con-




sists of a glass cylinder (A), with a flexible tube (B) running from its lower

part or chamber, for insertion, by means of a quill or hollow probe, into the vein to be injected: the upper part of the cylinder is provided with a stopper, through which a tube passes, connected with a small pair of hand bellows (D). Within the cylinder is a small hollow ball (E), or safety-valve regulator, which floats if there be fluid in the cylinder until the fluid allows it to descend to the constricted lower part of the cylinder, when all further passage of fluid is prevented. The flow of fluid along the escape-tube can be checked, or set at liberty at pleasure by the clip (C).

In using this instrument, first place the fluid to be injected in the cylinder (A) and let a little run through the escape-tube (B) to displace all the air; next close the escape-tube by means of the clip (C); then, having opened the vein or artery, while it is being pressed upon from above, insert and fix the quill or hollow probe at the end of the escape-tube, and, when all is ready for the fluid to flow, remove the clip and raise the cylinder two or three feet above the subject. The ordinary fluid-pressure will now usually suffice to carry the fluid into the body equably and gently; but if there be any obstruction, the merest pressure of the lower ball of the hand bellows will remove it. As the fluid descends, the hollow ball goes down with it to within three inches of the bottom of the cylinder, where it is opposed by the constricted neck, and where it effectually closes in all that is below it, so that no air can possibly get into the blood-vessel.

Reverting to the experiments related above, they, although negative as regards the particular object in view during their performance, teach an interesting and useful physiological lesson. They illustrate that when in the living body the nitrite of amyl, after its inhalation, excites the heart to such vigorous action, producing suffusion of the skin and the other extreme symptoms of excitation, the effect is conducted solely through the nervous system. I believe that the action of the nitrite, telling, at the moment of inhalation, upon the extreme filaments of the olfactory nerves, as well as on the pneumogastric tracts, communicates a peculiar and rapid motion, which traverses them and, without any indirect action on the blood, reaches the heart, giving to it impulse and vehemency of action.

The experience of every-day life tells us that the heart may be thrown into similar activity by impressions or influences communicated from the external world to the senses, and through them to the heart. The influences of sounds, harsh or melodious, of sights, appalling or fascinating, are well known, from the manner in which they come upon us. From their invisibility of action, if I may be allowed such an expression, we are prone to look on them as immaterial agents: they are not so; thoroughly understood they are as material as a physical blow, or the impress of a liquid or gaseous substance.

Nitrite of amyl is one of those substances which enable us to realize this connexion between the really material and the seemingly immaterial influences which surround us. We take an appreciable quantity of it, say, half a grain, and inhale it from paper, and at once we feel a quickened action of the circulation so decisively that we trace the effect immediately to the cause: we could, if we liked, quicken the heart to absolute silence by pushing the cause far enough. Here there is no mistake, no possibility of mistake. But we can modify the experiment and refine upon it. By admixing the vapour of ammonia with that of amyl, and diffusing the combined vapours through a large space of air confined by walls and closed windows, we can charge a room with a compound which the olfactory sense, as such, does not detect, but which tells with active and peculiar force upon the heart. In this way an invisible

and, as it would seem to the unlearned, an immaterial agency acts by known rules and in obedience to the human will *.

The day will soon come when we shall know the mode by which these agencies act upon the body through the nervous expanse: we shall follow out the living organism as so much matter moveable and transformable or transmutable, built in, and I had almost said upon, a refined medium, itself unchangeable, all-pervading, and establishing a bond of union between our own material parts, ourselves, our planet, our universe. We shall see how this fluid, itself physical, subjected to various influences, is disturbed, and how it communicates such disturbance to the grosser matters which it permeates; then a vast number of strange and, as they now appear to us, conflicting phenomena will resolve themselves into a single and simple law, and physiology, in its wholeness, the science of the sciences, will be the most useful and the most exact.

I have said that when the motion of the heart has once been stopped, the influence of the nitrite of amyl ceases; that the nitrite can quicken the living action, but cannot restore the lost action. These are the facts as they stand at the moment; but I must add as a qualification that the negative result may perchance be due to inadequacy of experiment, and that new and continuous experiment may change the argument.

### The Amyls as Antiseptics.

The second new line of inquiry to which the amyl-compounds were subjected, was to determine whether they could be turned to account, practically, as antiseptics. I had already found that every one of the series is preservative, and I therefore took one (the acetate) and subjected it to special inquiry. The reason for taking the acetate (essence of pears) was that it is most easily obtainable, is comparatively innocuous, and is removed entirely from any organic substance by the process of cooking.

The experiments were made in the following manner:—

1. By placing organs of soft texture of dead animals, such as the spleen, kidneys, and liver, in lightly closed earthenware chambers, in which the acetate of amyl was also placed, in a small open dish, or in cloth or sawdust.

2. By painting over the substance to be preserved with a mixture of size and acetate of amyl.

3. By injecting the body of a rabbit through the arteries with a fluid consisting of glycerine, water, and acetate of amyl.

4. By subjecting the quarters of a sheep to a solution of acetate of amyl, and then burying the parts in melted fat or melted size.

The results of the experiments are as follow:—

By the first method, animal substances may be preserved fresh when the temperature is below 46° Fahr. for three weeks; and when the temperature is above 46° and under 65° for a week. When the temperature is over 65°, the effect of the acetate is very uncertain. The change that takes place in the meat when the effect of the acetate ceases, is a change differing from ordinary putrefaction; it is a process of white odourless softening.

The second method, that of painting over the surface with a gelatinous envelope containing acetate of amyl, was not successful.

The third method, that of injecting the tissues by the arteries, is a good method. The body keeps well, even when exposed to the air at 60°, for four-

* I could make every heart in a room rise ten beats, at least, within a minute without diffusing a detectable odour, as surely as I could vary the motion of a steam-engine by moving the lever.

teen days. I have no doubt that animals injected in this way might be transported wholesale, if enclosed in boxes, during a voyage of three weeks or a month.

The last method, that of bringing the structure into close contact with the amyl-compound, was not successful. I gathered from all these experiments that as antiseptics the amyls require to be so applied that they diffuse through the tissues, and that they continue to act until they are carried away.

## ON THE PHYSIOLOGICAL ACTION OF SOME COMPOUNDS OF THE ETHYL SERIES.

Turning from these amyl-compounds, I have next to report on some of the bodies belonging to the ethyl series. For many centuries the ethers have been known and studied as substances possessing peculiar powers over animal bodies; and of late years their use as anæsthetic substances for general and local purposes has given to them additional interest.

The compounds of ethyl which I have specially studied are the oxide, the acetate, the nitrite, and hydrofluoric ether.

### Oxide of Ethyl.

The first of these, commonly known as pure ether, rectified ether, or sulphuric ether, is a substance that has been of great interest to the modern physiologist, owing to the fact that it has been applied largely for producing general insensibility to pain by the process of inhalation, and more recently by the local process of evaporation.

Although largely demanded for the first of these processes, the oxide of ethyl that has been sold for the purposes of the medical physicist has been most imperfect. The absurd rule of the Pharmacopœia, which allowed a certain small admixture of alcohol with ether, was the loophole through which the most flagrant abuses were permitted to find way. In fact, when at the commencement of the present year I required oxide of ethyl on a large scale, I could not for many weeks obtain any pure specimen that was not specially made for me: there was no uniformity either in respect to specific gravity, boiling-point, or reaction. These facts fully account for the great diversity of the opinions that have been expressed relative to the action of ether on the bodies of men and animals. The process for obtaining a pure oxide of ethyl is nevertheless very simple, and demands only care, patience, and honesty. Since February last, two thousand pounds weight of absolute ether have been sent out from one London house alone, that of Robbins and Company of Oxford Street.

The pure substance is a colourless, almost inodorous fluid; its specific gravity is 0·716 to 0·720; and 88° Fahr. may be taken as its mean boiling-point.

With a pure and reliable oxide of ethyl, I have been enabled to study the physiological action of the substance with a precision not before attained.

To produce a decided effect on the body of a warm-blooded animal by means of ether, it is best to administer the substance in the form of vapour, charging the air with from twenty to twenty-five per cent., and sustaining the supply steadily. The sensations produced are from the first pleasurable; there is expansion of idea in relation to space and to objects, then confusion with a peculiar sensation of sweetness in the mouth, and at last oblivion. The ether being withdrawn, recovery is very rapid indeed, so rapid that there is scarcely any perceptible stage of recovery: it is a sudden awaking to complete consciousness. In this respect ether closely resembles amylene in its action.

If inferior animals be subjected to absolute ether, and the influence of the vapour on their lungs, heart, and blood be carefully observed, we find that the lungs undergo a slight congestion, that the heart is filled with blood on both its sides, and the venous blood in its transit through the pulmonic circuit ceases to become arterialized. At the same time there is no destruction of the parts of the blood, and the process of coagulation is unaltered. When death is induced by pure ether, the event occurs by arrest of respiratory power. It occurs much in the same way as in death by drowning or by suffocation in carbonic acid. It is a great point to state, and it is most strictly true, that absolute ether has no directly poisonous action upon the heart. I have seen good pulsation of both sides of the heart for forty-five minutes after what may be considered the death of the animal. For this reason the action of absolute ether contrasts most favourably with chloroform. Chloroform kills by its paralyzing action upon the heart; hence when chloroform becomes deadly, it is inevitably deadly because it becomes impossible to remove it from the parts on which it acts to destroy. Ether, on its side, when it begins to cause embarrassment, is acting simply upon the respiration; and it is only necessary to cease to administer it to ensure recovery.

On the whole, after a most careful comparison of the action of absolute oxide of ethyl with the action of other volatile substances possessing anæsthetic properties, I claim for it that it is the safest of all known anæsthetics, that any indifferent effects arising, in past times, from its employment were due to badness of the article, and that science, not less than regard for human life, bids us, when a general anæsthetic is absolutely necessary, go back to ether as the safest agent.

In order to ascertain what would be the effect of actually impregnating the whole body of an animal with absolute ether, I injected one ounce of it into the aorta of an animal (a rabbit) already rendered insensible by the vapour. The result was that the fluid injected began to boil rapidly in the tissues with a free escape of ether-vapour, followed by a sudden, almost instant stiffness affecting the muscles of the whole body. This effect was due to the rapid extrication of heat from the tissues. It was a kind of general freezing of the tissues.

### Acetate of Ethyl and Hydrofluoric Ether.

The acetate of ethyl and hydrofluoric ether are chiefly remarkable for their powerful solvent action on all the tissues of animals. They can neither of them be safely administered by inhalation, but both of them may admit of being largely and usefully employed for the destruction and removal of morbid growths. Directed on the blood they break it up absolutely, destroying alike the corpuscles, the fibrine, and the albumen. In short, hydrofluoric ether may be looked on as a universal solvent of the animal tissues; nothing escapes its action except the gelatinous structures, and these not altogether.

### Nitrite of Ethyl.

The nitrite, or more correctly the hyponitrite of ethyl, nitrous ether, is made in a similar manner to nitrite of amyl, the difference being that the nitrous fumes are passed through *ordinary* alcohol. The fluid when pure is of a light amber-colour; the specific gravity is 0·950, and the boiling-point 60° Fahr. The physiologist who would work with it, should mix it with absolute ether in fixed proportions—say, of ten, twenty-five, or fifty per cent. It is so volatile that without this precaution it cannot be readily employed.

The action of nitrite of ethyl, as Professor Wanklyn suggested last year,

is closely analogous to the action of nitrite of amyl. Inhaled in quantities of not less than a grain, it induces the same sensation of fulness of the head, rapid action of the heart, and some suffusion of the skin. Animals subjected to it in the proportion of fifteen minims diffused as vapour through a cubic foot of air, die almost instantaneously from sudden failure of the heart, but even up to the moment of death they retain their consciousness and sensibility. The nitrite, consequently, is in no sense to be regarded as an anæsthetic.

Precisely as the nitrite of amyl, nitrite of ethyl, when it kills, leaves the lungs entirely collapsed and so perfectly white that one could assume they had been carefully washed free of blood. This effect is due perhaps to the rapid contraction of the pulmonary capillaries. The blood is changed in colour, the arterial blood being rendered very dark, and the venous of a deep chocolate tint*; the muscles are also all left blanched, as if the death had occurred from loss of blood.

It will be remembered that, in describing the action of nitrite of amyl, I explained that in cold-blooded animals the substance suspended their animation, and that frogs that had been rendered powerless by it, and to common observation inanimate, would sometimes spontaneously recover even so long as nine days after the administration. This same phenomenon I have observed with nitrite of ethyl, together with another even more singular. It is this. If a young animal, say a kitten, be subjected so suddenly to the nitrite as to fall senseless and to appearance dead in or within the minute, it will remain in the same state for six or even ten minutes, yielding no evidence of life: it will not breathe, and the most delicate auscultation will fail to detect motion of the heart. But after a period varying from six to ten minutes it will spontaneously recommence to breathe, and with every movement of expiration a breath sufficient to dull a mirror will pass from the nostril. As the breathing recommences, the heart also begins its work, making a series of distinct intermittent strokes. This condition, looking like an actual return of life, will last so long as half an hour, and will then cease gradually, the animal lapsing again into a state of actual inertia or death.

In concluding this Report I would place the facts I have collected, in respect to the ethyl series, as follows:—

1. Oxide of ethyl, or pure rectified ether as it is commonly called, is the best of all known agents for the production of general anæsthesia by inhalation.

2. The peculiar difference of action between the oxide of ethyl and the nitrite of ethyl is due to the introduction of a new element, nitrogen, into the latter compound. This difference of composition makes the nitrite approach, in action, bodies of the alkaloidal class, strychnine and its analogues.

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## *Second Report on the Structure and Classification of the Fossil Crustacea.* By HENRY WOODWARD, *F.G.S.*

I HAVE now to submit a Second Report upon the Fossil Crustacea, which have for some years past occupied my attention. Since the last Report made to the British Association in Birmingham in 1865, I have described and figured a new Liassic Crustacean from the Lower Lias of Charmouth—the

* The coagulation of blood is not modified.

*Æger Marderi*—a genus hitherto characteristic of the Solenhofen Slates of Bavaria*.

The following new genera and species of Crustacea were communicated by me to the Geological Society on the 23rd May last, and will appear in the next part of the 'Quarterly Journal' of that Society:—

"2. 'On a new Genus of Phyllopodous Crustacea from the Moffat Shales (Lower Silurian), Dumfriesshire.'

"The fossil described consists of the disk-shaped shield or carapace of an Apus-like Crustacean, the nearest known form to it being *Peltocaris aptychoides*, Salter, from which, however, it is at once distinguished by the absence of a dorsal furrow.

"A line of suture divides the wedge-shaped rostral portion of the shield from the rest of the carapace, the two parts being seldom found together. From its strong resemblance to *Discina*, the author proposed for it the generic name *Discinocaris*, and named the species *Browniana*, after Mr. D. J. Brown, who first drew his attention to it.

"3. 'On the Oldest known British Crab (*Palæinachus longipes*, H.W.) from the Forest Marble of Malmesbury, Wilts.'

"The author stated that three genera and twenty-five species of Brachyurous Crustacea had already been described by Professor Reuss and H. von Meyer from the Upper White Jura of Germany; but as no limbs or abdominal segments had been met with, it was more doubtful where to place them than the species now described, which had nearly all its limbs *in situ*, and a portion of the abdomen united to it. *Palæinachus* closely resembles the common Spider-crabs (the *Maiadæ* and *Leptopodidæ*) living on our own coasts.

"4. 'On the Species of the genus *Eryon*, Desm., from the Lias and Oolite of England and Bavaria.'

"The genus *Eryon* of Desmarest was established for certain extremely broad and flat forms of *Astacidæ* found in the Solenhofen limestone near Munich, and first described in 1757. The late Dr. Oppel has recorded fourteen species, two of which, *E. Barrovensis* and *E.* (*Coleia*) *antiquus*, are from the Lias of England. Mr. Woodward gave descriptions and figures of *E. Barrovensis*, M'Coy, and five other species, namely:—*E. crassichelis*, *E. Wilmcotensis*, and *E. Brodiei*, from the Lower Lias; *E. Moorei*, from the Upper Lias of Ilminster; and *E. Oppeli*, from the lithographic stone of Solenhofen."

The plates exhibited form (with one other) the first part of the Monograph on the *Merostomata* for the Palæontographical Society, and will be published shortly†.

I have lately had the opportunity to examine specimens of *Limuli* from the Coal-measures of Kilmaurs, Dudley, and Coalbrook-dale, and am happy to state that they have enabled me in the most satisfactory manner to demonstrate the connexion between this division of Crustacea and the older *Eurypterida* on the one hand and the recent King-crabs on the other. (See Report, Section D‡.)

The forms which occur in this zone (the Pennystone Ironstone) differ from *Limulus* in the less anchylosed condition of their segments and the possession of three well-marked divisions, representing the head, thorax, and abdomen, the latter being represented by three anchylosed segments, and having the intervening segments of the thorax free and unarticulated.

* See Geol. Mag. 1866, vol. iii. p. 10, pl. 1.
† They have since (Dec. 1866) appeared.
‡ Also Quart. Journ. Geol. Soc. vol. xxiii. p. 28.

The best example of this is the *Belinurus reginæ* of Baily, from the Irish Coal-measures; then follows the *B. trilobitoides*, of Buckland, the *B. anthrax*, Prestwich, the *B. arcuatus*, Baily, and lastly, the *B. rotundatus* of Prestwich. By placing these forms in the order indicated, we find a gradual change from the less to the more anchylosed condition of the body-segments, which attains its greatest concentration in the recent *Limulus*.

But besides these, we have in *Hemiaspis* a form more separated into distinct segments than is *Belinurus reginæ*; so that the passage from *Eurypterus* to *Belinurus*, and from that again to *Limulus* proper, seems capable of being bridged over, and we are justified in placing them in the same order, though separated into distinct subdivisions.

We have adopted Dr. Dana's name of MEROSTOMATA for the order, making the first suborder, EURYPTERIDA, to contain:—

A.

1. *Pterygotus*, Agassiz, having 14 species.
2. *Slimonia*, H. W., „ 3 „
3. *Stylonurus*, H. W., „ 6 „
4. *Eurypterus*, De Kay, „ 20 „
5. *Dolichopterus*, Hall, „ 1 „
6. *Bunodes*, Eichw., „ 1 „
7. *Arthropleura*, Jordan, „ 1 „

B.

8. *Hemiaspis*, H. W., „ 5 „

51 species.

Second suborder, XIPHOSURA, to contain:—

A.

1. *Belinurus*, König, having 5 species.

B.

2. *Limulus*, Müller „ 14 „

19 species.

I characterize the order MEROSTOMATA as Crustacea having the mouth furnished with mandibles and maxillæ, the appendages to which fulfil the functions of limbs, becoming walking- or swimming-feet, and organs of prehension.

Suborder EURYPTERIDA, Huxley, 1859.—Crustacea with numerous free thoracico-abdominal segments, the first and second of which bear one or more broad lamellar appendages upon their ventral surface, the remaining segments being devoid of appendages; the anterior rings united into a carapace bearing a pair of larval eyes near the centre, and a pair of large marginal or subcentral eyes; the mouth furnished with a broad postoral plate or metastoma, and five pairs of moveable appendages, the posterior of which form great swimming-feet,—the telson or terminal joint being extremely variable in form, and the integument characteristically sculptured.

XIPHOSURA (Gronov.).—Crustacea having the anterior segments welded together to form a broad convex buckler, upon the dorsal surface of which are placed two larval frontal eye-spots, and two large lateral compound eyes. Beneath this shield-like covering is placed the mouth, furnished with a small labrum and a rudimentary metastoma, and six pairs of moveable appendages. Posterior segments of the body more or less free in the fossil species, but anchylosed together in the recent species, and bearing upon their ventral surfaces a series of broad lamellar appendages. The telson or terminal segment ensiform.

I have prepared a Table which gives the species in detail, with their geological position and locality (it includes ten genera and seventy species*); also representations of all the genera save three, which require further confirmation before they can be figured otherwise than as fragments.

The geological range of this order is as follows:—We find there are 37 species in the Upper Silurian; 7 in the Lower, and 8 in the Middle Devonian; 1 in the Lower Carboniferous, and 7 in the Upper; 1 in the Permian of Russia; 1 in the Trias of Germany; 7 in the Lithographic stone of Solenhofen; 1 in the Tertiary Brown Coal of Saxony; and 4 living species inhabiting the shores of Molucca, Japan, China, the East Indies, and the eastern shores of North America. They have been met with geologically in the State of New York, especially in Buffalo county; in Ireland (Kiltorcan, fragments only); in Forfarshire, Lanarkshire, Fifeshire, and Caithness in Scotland; in Herefordshire, Worcestershire, and Staffordshire; in the islands of the Baltic (Oesel and Gothland); in Bavaria, Saxony, Poland, and as far east as the government of Perm and the Ural Mountains; so that their geological distribution is quite as wide as that of their living congeners.

The *Limulus* of the Upper White Jura cannot, so far as we are acquainted with it, be well separated generically from those of the present day. How vast, then, must have been the period represented between the lifetime of the *Belinurus* of the Coal-measures and that of the *Limulus* of the Oolites! and yet we should be unwilling to doubt their relationship by descent. Each antecedent period, then, must have been infinitely greater as we recede to the Wenlock, where the first traces of *Pterygotus* occur.

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*Second Report on the "Menevian Group" and the other Formations at St. David's, Pembrokeshire.* *By* H. HICKS, *and* J. W. SALTER, *F.G.S.*

THE work of the past year has not been confined to procuring fossil specimens, although that object has been kept steadily in view.

The extent and direction of the various beds has been particularly noted: and a much greater area than was formerly suspected has been found occupied by the respective lower fossil groups Menevian, Ffestiniog, Tremadoc, and the great Arenig or Skiddaw group—formations which have only of late years been accurately explored.

Above these rocks, and forming their upper limit, we have in the St. David's promontory the Llandeilo flags, a formation that does not need a special description, since it is already well known to us in the 'Silurian System,' and under the name of Lower Bala in Prof. Sedgwick's works.

The fossil-bearing strata in the neighbourhood of St. David's are mostly exhibited in coast sections; and the grant has been very useful in enabling Dr. Hicks to employ boat-service in the work. Without boats, indeed, it would be impossible to make sure of the succession, so much have the strata been disturbed and faulted, and also in many parts covered by drift. But the series, once accurately defined by this examination, could be tested by reference to roadside and brook sections, where the beds are weathered; and hence we can now offer a tolerably accurate map of all the formations, and extend it over a larger part of the district. Moreover in all about sixty-five

* This Table has since been published by the Palæontographical Society.—Dec. 1866.

or seventy new or partly described species have been found peculiar to this region, and these wait for description.

That the additions to the geology of St. David's during the last few years may be more clearly understood, it is well to state what formations are now known to be present in the promontory that forms the north shore of St. Bride's Bay. The Survey Map does not profess to subdivide the slate-rocks and volcanic grits, but only to separate these as a mass from the purple and grey sandstones coloured as Cambrian rock (the Harlech group of Professor Sedgwick).

In ascending order we have then:—

1. *The Harlech Group* (Sedgwick), consisting of purple and greenish-grey sandstone, passing above into grey sandstones (not grits) which are fossiliferous.

This mass of purple and greenish-grey flags forms the axis of the promontory, thrown into a violent anticlinal along the line of the so-called "syenite," which is partly altered Cambrian rock, and partly crystalline rock, perhaps syenite in some places.

2. *The Menevian Group*, 1500 or 1600 feet thick, of dark-grey (and even black) flags and shales, alternating in its upper and larger portion with sandstone. This is the great fossiliferous group.

3. *Ffestiniog Group* (Sedgwick).—Hard siliceous sandstone with grey flaky slate, containing *Lingulella Davisii*.

4. *Tremadoc Group*.—Sandstones and earthy slates, much like those of the Ffestiniog group, but of a bluish-grey colour and more uniform texture.

5. *Arenig or Skiddaw Group*.—A thick series of iron-stained slates and flags, interlined throughout by felspar lines and felspathic ashes, containing large Trilobites and shells of new species, and Graptolites like those of Skiddaw.

6. *Llandeilo Flags*.—Black slates, with felspar beds and interbedded trap, fossils abundant.

We may now give a few explanatory details, as brief as possible, respecting each of those formations:—

1. Concerning the Harlech group, it must be noted that the sections on the south coast (Caerbwddy for instance) show a distinct passage downwards into the central syenitic mass, so gradual as to induce the belief that the mass of rock is no other throughout than altered Cambrian beds. Near St. David's the same thing is visible. Altered purple beds close to the town are succeeded by rock apparently crystalline, but showing distinct rounded grains of quartz (as minute pebbles) throughout the mass. It is evidently a slightly altered grit or conglomerate. In other places further east, the rock is certainly melted in its central portions, but passes so gradually into olive shales through hardened flinty beds and hornstones, that no true boundary can be traced.

The series of sandstones, purple, green, and grey, which succeed are laid down with tolerable accuracy on the Survey Map (except where bounded by the prevailing faults). All the accessible localities have been searched for fossils, but with no success until the highest portion was reached; immediately above the topmost purple bands, 160 feet or so of these top beds contains fossils, not many species, but of the genera *Paradoxides*, *Conocoryphe*, *Agnostus*, *Theca*, and a new genus, *Cyrtotheca*.

These are of much the same character as those *of the next group, though the Trilobites differ specifically*.

2. *Menevian Group*.—The list of fossils belonging to this group is now

extended to more than forty species. Their distribution remains precisely the same as that elaborated in the last Report. The greater number of species occur with the largest *Paradoxides, P. Davidis*, which is the uppermost of the three forms known; *P. Hicksii* occurs at the base of the really dark shales, close upon the grey beds of the Harlech group just mentioned, in which group, 200 feet down, lies, as before noted, the *P. Aurora*.

It is worth notice that these three species, with their accompanying smaller forms (*Conocoryphe, Theca, Agnostus* with each), keep close to their own particular domains, the species of *Paradoxides* being never found mixed together. This may serve to show how very perceptible a change of fauna may occur within moderate limits; for the section is perfectly continuous, and yet these Trilobites are confined to narrow bands and do not reappear.

A species of *Orthis*, with few large plaits, has been found this year, the minute predecessor of all the *Orthis tribe*. Hitherto nothing but horny species of Brachiopods (*Lingula* and *Discina*) has been known to occur in these old beds; and one or other of these go down to the very base, while the *Orthis* is only found above the limit of the highest *Paradoxides*-beds.

[The fossils exhibited gave a general idea of this old fauna; a much larger series is sent to the British Museum and Jermyn Street.]

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3. With respect to the Ffestiniog group, or true Lingula-flag beds, we find this formation occupying its right place, at the very top of the *Menevian group*. It occurs in a faulted patch in Whitesand Bay; and forms a bold but narrow synclinal at the mouth of Solva Harbour and the Cradle Rock. It also occurs, of diminished thickness, in the district lying between the granite of Brawdy and Asheston and the syenitic axis. Upon it lies a trough of—

4. *Tremadoc Beds*, or what we regard as such. They have only this year been worked out fully. And lying as they do upon the true Lingula-flag and under the Arenig or Skiddaw slate, they can hardly be anything but Tremadoc beds. They graduate by insensible degrees from the Lingula-Sandstones, first as bluish-grey slate, and then earthy grey thick-bedded rock of a peculiar tough texture, and contain the following fossils:—

*Calymene*, 2 species.
*Homalonotus*, 1 species.
*Asaphus*, a giant species and a smaller one, the former all but undistinguishable from the *Asaphus Homfrayi* of the Tremadoc rocks.
*Orthoceras*, with peculiar arched striæ.
*Nucula* or *Ctenodonta*, 2 or 3 species.
*Orthis Carausii*, a coarse-ribbed fossil, highly characteristic of these beds.
*Orthis*, a fine-ribbed species like *O. elegantula*.
*Bellerophon, Lingula, Obolella*.

Now this fauna is wholly unlike the deep-water fauna of the Tremadoc region. It is evidently a thin formation, deposited in much shallower water: and this may be the reason of the great change in the fauna.

But there is something peculiar in the absence of the recognized upper beds of the *Lingula-flags* as they exist in North Wales. *Instead of a recurrence of black slate for the Upper Lingula-flags and lower portion of the Tremadoc group (forming a very thick set of* formations deposited in deep water), we have only a thin series of comparatively shallow water accumulations, marked by abundance of worm-tracks, and the fossils above quoted. This gives a marked character to the series, and indicates the following succession up to this point:—

(1) *Shallow-water or shore beds for the Harlech group.*
(2) *Slow depression for the Menevian group.*
(3) *Shallow-water or shore accumulations for the Lingula-flag.*
(4) *Gentle depression for the Tremadoc.*
(5) And, lastly, *deep and decided depression* of the sea-bed to receive the next great formation—the Arenig Rocks (Lower Llandeilo, Murchison).

5. *Arenig or Skiddaw Rock.*—A formation at least a thousand feet thick, of vertical beds of black shale, seen in Whitesand Bay, and occupying also more than half of *Ramsey Island*, where they lie in a distinct trough of *Tremadoc* and *Lingula-flags*; and everywhere characterized by the following fossils:—

*Ægliua*, 2 species.
*Ogygia*, 2 large species. *O. peltata* and *O. bullata.*
*Asaphus*, a large species.
*Trinucleus*, 2 species.
*Ampyx*, n. sp.
*Agnostus, Orthis, Lingula, Theca, Bellerophon.*

And, lastly, branched and twin Graptolites, viz. *Dendrograpsus* and *Didymograpsus.*

No Graptolites occur beneath the Skiddaw group in Britain. And though all these species, except the Graptolites, are distinct from the fossils of the same strata in North Wales and Shropshire, the probable reason is, that the latter were in shallow water, while ours is evidently, like the Skiddaw slate, a deep-water series. We may therefore expect these species to be found in Cumberland.

Ramsey Island is worth a visit; for the exhibition of the three sets of rocks (*Lingula-flag, Tremadoc,* and *Arenig*) is very complete on the north side of the island, and fossils are abundant.

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6. To complete the geology of St. David's, one must go to the overlying Llandeilo flags of Abereiddy Bay. These fine slate-quarries are full of fossils. Trilobites of well-known forms, familiar to us at Builth and Llandeilo, crowd the slaty bands, and Graptolites in myriads, principally the species called the *tuning-fork graptolite* (*Didym. Murchisonæ*). The chief Trilobite is *Ogygia Buchii*; but there are many other Builth species, and some very rare ones, *Barrandia Cordai*, for instance. A few words on the faults of the district, which are literally innumerable.

*E. and W. faults*, sometimes of large amount, but not much indicated on the surface.

*N.N.W. ones*, more conspicuous as lines of valley and marsh; often shifting the strata much, and giving outline to the coast.

*N.E. faults*, frequent, but not of very large amount; have not been well observed.

*N. and S. faults*, believed to be the latest, and they give much impress to the features of the district, forming short valleys, and shifting the strata, but less than the others.

*Summary of the facts stated.*

1. We have two axes of elevation in the promontory, viz. the granite of Brawdy and Asheston on the *south-east*, and the so-called St. David's syenite in the centre. The latter is chiefly altered rock.

2. Between these two axes, and on either side of them, the purple and grey Cambrian rock forms a steep trough, supporting black shales of the Menevian group, followed by Lingula-flag and Tremadoc rock, and on the north side of the coast Arenig or Skiddaw rocks covered by Llandeilo flag.

3. The conditions of deposit seem to be, that the Harlech group was nearly uniform with that of North Wales, but, being of finer grain, indicates a somewhat deeper-water deposit. The *Menevian*, *Lingula-flag*, and *Tremadoc* rocks are all much thinner, and, as a rule, of more even deposit, than in North Wales. They, too, seem to have been formed far out at sea, but probably in no great depth of water.

The depression in the Arenig and Llandeilo groups seems to have been greater, and particularly in contrast with the conditions of deposit in North Wales and Shropshire, where shore accumulations were being everywhere laid down. But in this respect they are more like the Skiddaw slates, some of whose fossils they include; and the presence of repeated beds of lava, ash, and ashy slate lends no countenance to the idea that these beds were subject to the oscillations of a shallow sea; for the deposits are remarkably tranquil, fine-grained, and regular. Beds of fossils occur at intervals only in the Arenig and Llandeilo rocks, and are then plentiful, as in other deep-sea deposits. But the Tremadoc rocks, being apparently laid down on a stationary sea-bed, present us with conditions wholly unlike those of the same period in North Wales, and, perhaps as a consequence of this, with a very different set of organic remains.

The Harlech, Menevian, and Ffestiniog group have each large and well stratified beds of true contemporaneous volcanic rock, as well as many intruded beds.

J. W. SALTER.
HENRY HICKS.

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## *Report on Dredging among the Hebrides.*
### *By* J. Gwyn Jeffreys, *F.R.S.*

This exploration lasted nearly two months, viz. from the 24th of May to the 14th of July in the present year. It comprised Sleat Sound, Lochs Alsh, Duich, Slapin, and Scavaig, and the Minch from Croulin Island to Loch Ewe. I had a good cutter yacht, the master of which had been employed by me for many years as dredger and took considerable interest in the work, an active and willing crew, four serviceable dredges, 300 fathoms of new rope, machinery for hauling up the dredges, a large tub, sieves, and various other apparatus. The Hydrographer of the Navy obligingly supplied me with such charts as I required, to show the depths and nature of the sea-bottom in the district which I proposed to examine; and these were of great use in dredging, as well as for navigation. The weather was too fine; we were often becalmed for many hours together: and instead of steady breezes, we had too many of those squalls which are so prevalent, and occasionally dangerous, in the Hebrides.

The Hebridean seas have been often searched, but not explored, by zoologists. Their great extent, and the number of lochs and inlets which indent the coast in every direction, would render necessary an immense deal of money, time, and patience for a complete investigation. There is little probability that the subject of the present Report will ever be exhausted.

The Invertebrate fauna of this district is of a northern character, although there are a few exceptions. Such are, among the Mollusca, *Trochus umbilicatus*, *Phasianella pulla*, *Rissoa cancellata* or *crenulata*, *Odostomia lactea* or

*Chemnitzia elegantissima*, and *Pleurobranchus plumula*. These may be regarded as southern forms. The first and third occur as far north as Stornoway; the second ranges to Dunnet Bay in Caithness; of the fourth I dredged a single specimen in the upper part of the Minch; and the last lives between tide-marks in the Isle of Mull. As a set-off to the above, I would mention the following species, which have now for the first time been found so far south as the Hebrides, viz. *Montacuta tumidula* (a new species, which I will presently describe), *Trochus occidentalis*, var. *pura*, *Jeffreysia globularis*, and *Odostomia eximia*. The first is Swedish; the second is Zetlandic, Scandinavian, and North American, although it has also been procured in the Orkneys and on the Aberdeenshire coast; the third is Zetlandic, and the fourth Zetlandic also and Norwegian. It must be borne in mind, as regards the extent of geographical distribution, that the southern extremity of the Shetland Isles is distant about 200 miles from the northern extremity of the Hebrides, "as the fish swims." Besides the four last-named species, the following seem to reach their most southern limit in the Hebrides:—*Lima elliptica*, *Leda pygmæa*, and *Trochus Grœnlandicus*. *Leda pygmæa* has indeed been dredged on the coast of Antrim; but I am now inclined to regard the specimens thus obtained as quaternary fossils. *Tethea cranium* (a sponge not before known south of Shetland) occurred in tolerable numbers on the Ross-shire side of the Minch. Species of Mollusca, inhabiting the Hebridean seas, which are in the main northern (although they have been found somewhat further south, and some of them occasionally even in the Mediterranean), are—*Argiope cistellula*, *Pecten striatus*, *Mytilus phaseolinus*, *Modiolaria nigra*, *Crenella decussata*, *Nucula tenuis*, *Leda minuta*, *Arca pectunculoides*, *Montacuta ferruginosa*, *Cyamium minutum*, *Cardium minimum*, *Cyprina Islandica*, *Astarte compressa*, *Tellina pusilla*, *Scrobicularia nitida*, *Thracia convexa*, *Mya arenaria*, *M. truncata*, *Chiton Hanleyi*, *C. albus*, *C. ruber*, *C. marmoreus*, *Tectura testudinalis*, *T. fulva*, *Propilidium ancyloides*, *Puncturella Noachina*, *Emarginula crassa*, *Scissurella crispata*, *Trochus helicinus*, *Lacuna divaricata*, *L. puteolus*, *L. pallidula*, *Rissoa albella*, *Jeffreysia diaphana*, *J. opalina*, *Odostomia minima*, *O. albella*, *O. insculpta*, *O. diaphana*, *Velutina plicatilis*, *V. lævigata*, *Trichotropis borealis*, *Purpura lapillus*, *Buccinum undatum*, *Trophon Barvicensis*, *T. truncatus* or *Banffius*, *Fusus antiquus*, *F. gracilis*, *Nassa incrassata*, *Mangelia turricula*, *Defrancia scabra*, *Cylichna nitidula*, *Amphisphyra hyalina*, *Philine scabra*, *P. pruinosa*, and *P. quadrata*.

For certain species, which are almost peculiar to the Hebrides, I am not aware that any locality has been recorded between that district and the Mediterranean. Such are *Axinus ferruginosus*, *Poromya granulata*, *Neæra abbreviata*, *N. costellata*, and *Cylichna acuminata*. The first three of these were described by the late Professor Edward Forbes, in the Report to the Association in 1843 on Ægean Invertebrata. Another Hebridean species (*Nucula sulcata*) is not found southwards nearer than the coast of Spain.

Some of our most conspicuous and prized shells, that are also of a northern type, are wanting in the Hebrides. *Saxicava Norvegica*, *Natica Grœnlandica*, *Buccinum Humphreysianum*, *Buccinopsis Dalei*, *Fusus Norvegicus*, *F. Turtoni*, and *F. Berniciensis*, are in this category. All the above (with the exception of *Buccinum Humphreysianum*, which inhabits Shetland and the coasts of county Cork) are met with on the Dogger bank; and the first two are fossil in the Clyde beds. Six out of the seven being univalves, I would venture to surmise that their non-existence in the western seas of Scotland may have arisen from the circumstance that the diffusion of uni-

valves is slower than that of bivalves. The spawn of the former is attached to the spot where it is shed, or in a few cases (e. g. *Capulus* and *Calyptræa*) it is hatched within the shell of its sedentary parent; so that the fry form a colony, and need not roam to any distance, provided their station yields a sufficient supply of food and has the other requisites of habitability. Not so with bivalves. These shed their ova into the water, or else (as in some of the *Kellia* family) hatch them within the folds of the mantle, whence they are excluded on arriving at maturity. Their fry swim freely and rapidly by means of numerous encircling cilia. The metamorphic state lasts many hours. During that period they can voluntarily traverse considerable distances, or they may be involuntarily transported by tidal and oceanic currents. Time is the only element necessary for their widest dispersion over the adjacent seas, if no barrier intervenes. Should, however, such an obstacle present itself, whether in the shape of previously existing dry land, like that which separates the North Sea from the Atlantic, or from an upheaval and drying-up of the neighbouring sea-bed by geological or cosmical causes, the further diffusion of any marine animals in that direction must necessarily be stopped. An opposite result would doubtless be produced by a sinking and submersion of dry land below the level of the sea, whereby the diffusion of such animals would be greatly facilitated. This appears to have been the fluctuating course of events since the formation of the Coralline Crag, which was probably the cradle or starting-point of our molluscan fauna—a period long antecedent to the last glacial epoch, and incalculably far beyond the advent of man, unless his origin is much more remote than it is at present supposed to be. I am not inclined to attribute the northern character of some of the Hebridean mollusca to the persistence of what have been called "boreal outliers." The idea savours more of poetry than of philosophy or fact. The boreal or truly arctic species which once flourished in this district have become quite extinct, probably in consequence of one of those revolutions above suggested, by which the sea-bed was converted into dry land. These boreal species consist chiefly of *Rhynchonella psittacea*, *Pecten Islandicus*, *Astarte crebricostata* or *depressa*, *Tellina calcaria*, *Mya truncata*, var. *Uddevallensis*, *Trochus cinereus*, and *Astyris Holböllii*; and I have lately, as well as on a former occasion, dredged them on the coasts of Skye and West Ross, at depths of from 30 to 60 fathoms, or 180–360 feet. They had a semifossilized appearance. Not one of the above-named species has ever, to the best of my knowledge and belief, been found in a living or recent state in any part of the British seas. All of them occur in post-tertiary or quaternary deposits on the west coast of Scotland, from a few feet above high-water mark* to 320 feet above the present level of the sea†. The greatest subaërial height (320 feet), being added to the greatest submarine depth as above (360 feet), gives an extent of elevation and subsidence equal to 680 feet. But as *Pecten Islandicus*, for example, now inhabits the arctic ocean at depths varying from 5 to 150 fathoms, let us take the average of these depths, viz. 77½ fathoms or 465 feet, and add it to the 680 feet. This would make 1145 feet, and probably represent the height at which the sea-level may be supposed to have stood when *P. Islandicus* lived on the highest fossiliferous spot noticed by Mr. Watson. The non-fossiliferous boulder-clay, indicating the simultaneous presence of arctic land which was also subject to glacial conditions, is stated by Mr.

* British Association Report, 1862, Trans. Sect. p. 73: Jeffreys "On an Ancient Sea-bed and Beach near Fort William, Inverness-shire."

† Transactions of the Royal Society of Edinburgh, 1864, p. 526: Rev. R. B. Watson, "On the Great Drift-beds with Shells in the South of Arran."

Watson* to be about 800 feet higher than the mean deposit. The height of the layer of sea-shells on Moel Tryfaen in Carnarvonshire (evidently the remains of an ancient beach) exceeds that of the similar deposit at Cardigan by more than 1300 feet; and the difference of height observed in the case of other fossiliferous deposits in the north of England (*e. g.* Manchester and Kelsey Hill) shows that the disturbing movement has been unequal, and probably not synchronous, over the same area. It would seem that the extent of such oscillation has not altogether amounted to 2000 feet in the British Isles, taking Moel Tryfaen as the greatest height, and the Shetland sea-bed as the greatest depth, at which quaternary shells of recent species occur. The Scotch and Irish deposits, however, are on the whole far more ancient than those of Wales and England, judging from their geographical nature; the former are chiefly arctic, and the latter merely northern. Whether other parts of the North Atlantic sea-bed have undergone a much greater change of level since the tertiary epoch is not so well established. Dr. G. C. Wallich, in his admirable and philosophical treatise†, with which all marine zoologists and geologists are, or ought to be, familiar, believed that certain starfishes which he had procured at a depth of 1260 fathoms (7560 feet) in lat. 59° 27′ N., long. 26° 41′ W., about halfway between Cape Farewell and the north-west coast of Ireland, were originally a shallow-water species, but had gradually, and through a long course of generations, accommodated themselves to the abnormal conditions incident on the subsidence of the sea-bed‡. The starfishes in question, which he refers to the *Ophiocoma granulata* of Forbes (*Asterias nigra* of O. F. Müller), appear, however, to belong to a different species, which inhabits deep water. In an important paper by Professor Sars, on the distribution of animal life in the depths of the sea§, he states that *Ophiocoma nigra* (*O. granulata*, Forbes) is certainly found in shallow water, viz. from 2 to 30 fathoms, on the coast of Norway, but never at a greater depth so far as is yet known, and that it does not range north of the firth of Drontheim. He is of opinion that Dr. Wallich's species is *Ophiacantha spinulosa* of Müller and Troschel, a well-known and Grœnlandic species, which is not littoral, but rather a deep-water kind, viz. from 20 to 190 fathoms; and he infers from Wallich's own account that the last-named species, instead of *Ophiocoma nigra* or *granulata*, was the one taken by the 'Bulldog'-sounding in 1260 fathoms. Dr. Wallich also adduces his discovery, at a depth of 682 fathoms (4092 feet), in lat. 63° 31′ N., long. 13° 41′ W., of two testaceous Annelids, which he assumed to belong to "known shallow-water forms," as further evidence of an extensive submergence of the North Atlantic sea-bed. These Annelids were named by him *Serpula vitrea* and *Spirorbis nautiloides*. But Professor Sars disputes their being shallow-water species. The former he identifies with his *Serpula polita* (=*Placostegus tridentatus*, Fabricius); the latter is referred by Mörch‖ to the *Serpula spirorbis* of Linné. The one is regarded by Sars as a deep-water and not littoral species, being found on the Norwegian coast in 20–300 fathoms; the other has a wide bathymetrical range, from low-water mark to 300 fathoms. I suspect, moreover, that there has been some mistake in the determination of the *Spirorbis*, and that it belongs to another species than that to which Wallich has assigned it. As to the accuracy of his statement that he pro-

* *Loc. cit.* p. 524.

† The North Atlantic Sea-bed, 1862.

‡ *Loc. cit.* p. 41.

§ Vid.-Selsk. Forhandl. 1864: Hr. Sars, "Bemærkninger over det dyriske Livs Udbredning i Havets Dybder."

‖ Naturhist. Tidsskr. 1863: "Revisio critica Serpulidarum."

cured living starfishes from a depth of 1260 fathoms, under the circumstances which he has described (viz. "convulsively embracing a portion of the sounding-line, which had been paid out in excess of the already ascertained depth, and rested for a sufficient period at the bottom to permit of their attaching themselves to it"), no reasonable doubt can be entertained. I have myself seen a number of *Antedon* (or *Comatula*) *celticus* clinging to the rope several feet from the dredge when it was taken up from about 60 fathoms. These starfishes must have crawled up the rope while the dredge was in motion or being hauled in, because no part of the rope had lain on the ground. Dr. Carpenter tells me that *Antedon rosaceus* has the same habit of crawling up and clasping a rope in shallow water.

The greatest depth marked on the Admiralty charts in any part of the Hebridean sea-bed which I examined is 132 fathoms. Here I got several kinds of living Foraminifera. Nineteen years ago I dredged near the same ground, in 116 fathoms, a fine cluster of one of the compound Tunicata, *Diazona Hebridica*, of a greenish-pink colour. I do not mention this as a great or even considerable depth. Sars* and Koren† have done much more on the coasts of Norway; their dredging-explorations extended to 300 fathoms. In the paper from which I have extracted the above remarks as to the distribution of animal life in the depths of the sea, Professor Sars has enumerated no less than 52 species and distinct varieties of animals found by him at the depth of 300 fathoms. They may be thus classified:—Porifera (Sponges) 2; Rhizopoda (Foraminifera) 19; Polypi (Actinozoa) 7; Mollusca (Polyzoa 8, Tunicata 1, Mollusca proper 10) 19; and Vermes (Annelida) 5. He has also specified several Echinoderms, Cirripeds, and Crustacea as inhabiting somewhat less depths, viz. from 200 to 250 fathoms. The observations of the learned Norwegian zoologist confirm those of Sir James Ross and Dr. Wallich, namely:—

1st. That the temperature of the sea is uniform (39°·5 Fahr.) over the whole globe, below a certain line which forms an isothermal curve, with but slight oscillations caused by changes of the atmosphere. This curve has its greatest depth at the Equator, but reaches the surface of the ocean in lat. 56° 62′, and dips again as it approaches the pole from this point.

2nd. Although the pressure of the water is enormous at great depths, and in 300 fathoms is equal to about 56 atmospheres or 840 lbs. on the square inch‡, yet the most brittle and delicate animals (such as Polyzoa and Polypi) inhabiting such depths do not appear to suffer the slightest injury. Their structure is porous and permeable by liquids, or accessible to an endosmotic influence by which the pressure is easily resisted.

3rd. The want of light has always been considered an obstacle to the existence of animal life at great depths—not so much because light is directly essential to animal life, as on account of its indirectly contributing to its maintenance. It is generally supposed that animals are dependent on vegetable life. This latter (as is well known) cannot exist without light, under the influence of which the absorption of carbonic acid and the evolution of oxygen are effected. Light, however, exerts no such influence on animal life. Sea-weeds (the true Algæ) disappear in about 200 fathoms; and the only vegetable organisms which descend to a greater depth, say 400 fathoms, are Diatomaceæ. It may be observed, with respect to the action of light in producing colour in animals, that although intensity of light may produce

* Reise i Lofoten og Finmarken, 1849. † Nyt Mag. Naturw. 1856.

‡ The Norse skaalpund is 10 per cent. more than the English lb. avoirdupois. Sixteen Norwegian square inches are equal to seventeen English square inches.

a corresponding intensity of colour under ordinary circumstances, yet the diminution or absence of light in the sea is not necessarily followed by a diminution or absence of colour in marine animals. Those taken from considerable depths have frequently vivid colours. The animal of *Lima excavata* (a comparatively gigantic species), from 300 fathoms, is of the same bright red colour as those of *L. Loscombii* and *L. hians* from shallow water. It has been shown that violet and blue rays of light (and probably actinic rays) penetrate deepest in water. I will not here repeat what I have already published* on this interesting subject; but I may add that all the animals recorded as living at great depths are zoophagous, none of them phytophagous. The deep-sea dredgings of the Swedish Expedition to Spitzbergen in 1861 yielded some valuable results. Adjunct-Professor Torell and Professor Keferstein communicated some short and imperfect notices to the northern journals; but Professor Lovén has lately given us fuller information, which is published in the Transactions of Scandinavian Naturalists at their ninth meeting held in 1863†. A Brooke's lead and a 'Bulldog' machine, with several improvements, were used on this occasion. Depths from 6000 to 8400 feet (1000–1400 fathoms‡) were thus explored. The sea-bottom at these depths was covered with a fine greasy-feeling material of a yellow-brownish or grey colour, rich in Diatomaceæ§ and Polythalamia, and nearly devoid of sand. Professor Lovén was furnished with the notes of Messrs. Chydenius and Malmgren, made during the expedition, and with all the animals discovered in those great depths. The latter comprised:—Annelida, viz. species of *Spiochætopterus* and *Cirratulus*; Crustacea, viz. a *Cuma* which appeared to be identical with *C. rubicunda*, Lilljeborg, and an *Apseudes*; Mollusca, viz. a *Cylichna*; Gephyrea, viz. a fragment of *Myriotrochus Rinki*, Steenstrup, and another allied form with large and fewer star-wheels, and of smaller wheels of the *Myriotrochus*-type; a species of *Sipunculus* resembling *S. margaritaceus*, Sars; and, lastly, a sponge, in which were found a Copepod or Ostracod, and a fragment of a *Cuma* resembling *C. nasica*. In the opinion of Lovén these animals indicate, so far as can be judged by so small a number, that in the abysses of the glacial seas there lives a fauna which does not greatly differ from that which lives on the same kind of bottom at much less depths. Proceeding upwards to the surface, from 50 or 60 fathoms the regions or zones have a greater variety of animals, even over the same kind of bottom. Taking this into consideration, and also recollecting that in the Antarctic seas, at measurable depths, there are forms of Mollusca and Crustacea which exhibit partly generic, partly almost specific identity with northern and hyperborean forms, the idea occurs to him that, in depths of 60–80 fathoms and thence down to the greatest from which we hitherto know any animal life, at least wherever the bottom is covered with a soft and fine mud or clay, there exists from pole to pole, in all latitudes, a deep-sea fauna of the same general character, many species of which have a very wide distribution. He also thinks it probable that in the vicinity of both poles such a uniform fauna approaches the surface; while in tropical seas it occupies the depths of the ocean, the coast line there being represented by vast regions of distinct faunas, the circumferences or areas of which are much more limited. The

* British Conchology, vol. i., Intr. pp. xlviii–l, and vol. ii. Intr. pp. viii–xi.

† Stockholm, 1865, p. 384.

‡ The Swedish foot makes only 0·974 English foot. The Scandinavian fathom is 6 feet.

§ This does not quite agree with the accounts of Wallich and Sars, which give 400 fathoms as the limit of vegetable life; but it does not appear that the Diatomaceæ observed by Lovén had actually lived on the sea-bottom. They might have been pelagic and floating kinds.

sea-bottom, at considerable depths, differs in its composition. Professor Sars noticed that large Brachiopoda, stony corals, and Polyzoa, as well as certain Mollusca (e. g. *Anomia* and *Saxicava*), which are peculiar to a hard or even to a rocky bottom, inhabit a depth of 300 fathoms; and Dr. Wallich found a living *Serpula* attached to a stone at the depth of 682 fathoms. Captain Beechey's dredgings off the Mull of Galloway, in 145 fathoms (as reported by the late Mr. Thompson of Belfast in the Annals and Magazine of Natural History for September 1842, p. 21), yielded live specimens of *Chiton fascicularis*, *C. cinereus*, *Trochus millegranus*, and *Trophon Barvicensis*, all of which are inhabitants of hard or stony, and never of soft ground, besides dead shells of the same and similar species. The Hebridean sea-bed, at very moderate depths (which Dr. Wallich would call "shallow water"), mainly consists of a soft and more or less tenacious mud, mixed with stones of different sizes, and resembling in its composition the boulder-clay or glacial drift of Scotch geologists. It tells us of rocks ground down by glaciers year after year in an arctic region—of the mud produced by such attrition being carried into the sea in the thawing-season by overwhelming floods, "non sine montium clamore" (see Dr. Kane's description of the great Humboldt glacier)—of its dispersion over the sea-bed by the action of tides and currents—of the deposit thus formed being inhabited by a variety of animals of a high northern type during a long and quiet course of time—of the sea-bed being elevated by slow degrees above the surface of the water by an agency which we cannot satisfactorily explain, but which may have been volcanic or perhaps caused by steam*—of the consequent extermination of these marine animals—of an interval during which the raised sea-bed was dry land—of a gradual amelioration of the climate—of another oscillation of the earth's crust in a downward direction, when the surface of the land, covered by its former deposit, again became the bottom of the sea—and of a fresh succession of life, which is still in existence. Thus a cycle of similar events continually recurs. Nothing is lost or altogether perishes; all the old materials are used up, and assume new forms. It is the fashion to quote Lucretius. I will only indulge in two lines; they seem not to be inapplicable to the present subject:—

> "Huc accedit uti quicque in sua corpora rursum
> Dissoluat natura neque ad nilum interemat res."

The kind assistance of Mr. Alder, Dr. Carpenter, the Rev. A. M. Norman, Messrs. Henry and George Brady, Dr. M'Intosh, and Mr. Peach—all of them experienced zoologists—enables me to supplement this report with notices of other departments of the invertebrate fauna, which have resulted from the last grant made to me. Several new species, especially among the smaller Crustacea, have occurred; and our knowledge of geographical distribution has been not a little advanced by the work. Mr. Norman's services especially deserve acknowledgment.

I have made my usual contribution to the British Museum.

### *Description of a new species of* Montacuta.

MONTACUTA TUMIDULA†, Jeffreys.

SHELL rhomboideo-oval, rather gibbous, thin, semitransparent, glossy, and prismatic: *sculpture*, numerous and close-set, delicate, microscopical concentric striæ: *colour* yellowish: *epidermis* fine and silky: *margins*, on the

* *Vide* Mr. R. A. Peacock's pamphlet 'On Steam as the Motive Power in Earthquakes and Volcanoes, and on Cavities in the Earth's Crust.' Jersey, 1866.

† Somewhat swollen.

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posterior side extremely short and sloping downwards, without any of the angularity which characterizes *M. bidentata*; in front gently curved, on the anterior side considerably expanding and rounded; on the back rising towards the anterior end: *beaks* small, calyciform, blunt and prominent, incurved, but not having any indentation below them; they are placed close to the posterior side, which is the shortest and not one-sixth the size of the anterior side: *hinge-line* rectangular, occupying about one-third of the circumference: *cartilage* as in *M. bidentata*: hinge-plate narrow and strong, thicker in the middle, not excavated so deeply as in the last-named species, and scarcely at all in the right valve: *teeth*, in the right valve short, triangular, slightly inclining inwards, not widely separated; in the left valve long, erect, laminar, and parallel with the hinge-line; the anterior teeth are the largest in both valves: *inside* iridescent and polished, very finely marked (more distinctly on the anterior side) with slight lines which radiate from the beaks: *scars* irregularly oblong, conspicuous. L. 0·075. B. 0·1.

HABITAT. Muddy ground in the Minch, off the north-west coast of Ross-shire, in 50–60 fathoms. I there found only a single dead specimen; but twenty years ago I dredged another in Skye, which I deferred noticing until quite satisfied of its differing from *M. bidentata*. [Since this Report was presented, Mr. Dawson has found two more specimens in some of the dredged sand which I had sent him.] Among the shells procured by Professor Lilljeborg in Bohuslän, on the south coast of Sweden, I observed two or three specimens of the present species, one of which he kindly gave me.

This shell is smaller than *M. bidentata*; it may also be distinguished from that species by its narrower shape, being convex instead of compressed, having a glossy surface, and by the posterior side being extremely small, with almost a perpendicular truncation. That side in *M. bidentata* is invariably squarish, and more or less angulated. The teeth in the right valve of *M. tumidula* are much smaller, and less widely separated by the cartilage-pit; they are triangular instead of leaf-like, and slightly incline inwards instead of being erect.

*M. truncata* of Searles Wood, from the Coralline Crag, is a comparatively large, squarish, and flattened shell, and has long cardinal teeth.

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## *Report of the Committee appointed for the purpose of Exploring the Coasts of the Hebrides by means of the Dredge.*—Part II. *On the Crustacea, Echinodermata, Polyzoa, Actinozoa, and Hydrozoa.* *By the* Rev. ALFRED MERLE NORMAN, *M.A.*

Mr. JEFFREYS having, in his Report upon the Mollusca, already given to the Association an account of the district investigated by the Committee, and of the scope of their dredging-operations, it is unnecessary that I should add more on that subject; and I shall therefore proceed at once to lay before you a brief summary of the results of the dredging with respect to the Crustacea, Echinodermata, Polyzoa, and Cœlenterata.

Although the Hebridean seas had been frequently dredged by the naturalists who were well acquainted with the Mollusca, they had been scarcely at all examined by any one conversant with the other branches of the marine invertebrate fauna; and the result of the recent investigations has thus been most important. This will be at once evident when it is stated that, in addi-

tion to the knowledge which has been gained in the extension of the range of many rare and local species, not less than *seventy-two* species are in the present Report for the first time announced as members of the British fauna. These additions to our lists include 63 species of Crustacea [Macroura 1, Stomapoda 2, Amphipoda 8, Isopoda 1, Cladocera 1, Ostracoda 37, Copepoda 13], 6 of Polyzoa, 1 of Actinozoa, and 2 of Hydrozoa *.

The Crustacea obtained number two hundred and twelve species. Among them were two well-known southern forms, *Xantho florida* and *Xantho rivulosa*, which we little expected to find so far north; the latter, however, has been met with by Prof. Lovén in Sweden, though neither had previously been found on any part of the Scotch coast. They occurred in company between tidemarks at Tobermory, and *X. rivulosa* was also found at Oban. Another southern species, *Crangon sculptus*, which had not before been found north of Arran in Ireland, was dredged in the Minch; and with it was associated *Crangon serratus*, Norman, described by me at the British Association Meeting in 1861, from two specimens procured on the Haaf off Shetland. This species had not again been taken in our seas until the present time; but it has been redescribed by Professor Sars, from the Norwegian coast, under the name of *Crangon echinulatus* †. An *Hippolyte*, also dredged in the Minch, appears to be an undescribed species. It approaches to *H. turgida* of Kröyer‡, but differs in many particulars, and especially in the telson, which has no less than nine pairs of lateral spines, and terminates in thirteen spines, of which the nine central are subequal in length and ciliated on both margins. *Doryphorus Gordoni* (Bate), which has hitherto been regarded as very rare, occurred in abundance. Of the Cumacea there were found two species, recently added to our fauna, *Diastylis bispinosa*, Say (=*D. bicornis*, Bate), and *Endorella* (*Endora*) *emarginata*, Kröyer, together with two new forms, one a *Diastylis* allied to *D. biplicata*, G. O. Sars, the other a new *Iphithoe*, which has a crest of from 13 to 20 spines on the dorsal line of the carapace.

Several Norwegian Amphipoda, including some genera of great interest, were for the first time met with in our seas, namely, *Ampelisca carinata*, Bruzelius, *A. macrocephala*, Lilljeborg, and *A. tenuicornis*, Lilljeborg, *Eriopis elongata*, Bruzelius, and *Mœra Lovéni*, Bruzelius. There were also found an undescribed *Anonyx*, and two forms which it is impossible to assign to any genera which have been hitherto established; for these I propose the names *Euonyx chelatus* and *Microprotopus maculatus*. The genus *Euonyx* is allied to *Anonyx*, but is distinguished by having the first pair of gnathopods furnished with distinct chelæ, and the second pair more strongly formed than the first, with a well-developed subchelate hand. This is a parasitic species living on *Echinus esculentus*. *Microprotopus* is allied to *Microdeuteropus*, but has the first gnathopod feeble, the second largely developed in the male, and subchelate, and the last uropods single-branched.

Three parasitic Isopoda were taken—*Gyge Hippolytes*, Kröyer, *Phryxus*

* If to these we add *Montacuta tumidula*, n. sp., described in Mr. Jeffreys's Report, and the Foraminifera enumerated by Mr. H. B. Brady as occurring for the first time in our seas, viz. *Lagena Jeffreysii*, H. B. Brady, n. sp., *L. Lyellii*, Sequenza, *L. pulchella*, H. B. Brady, n. sp., *L. gracillima*, Sequenza, *L. crenata*, Parker and Jones, *Polytrema* ——, sp., *Hauerina compressa*, D'Orb., *Trochammina squamata*, Parker and Jones, *T. gordialis*, Parker and Jones, *Valvulina conica*, D'Orb., *Cristallaria cultrata*, Montfort, and *Marginulina raphanus*, L., we have a sum total of eighty-five species added to the British Fauna in this expedition.

† Sars, Vid. Selsk. Forh. i. Christiania, 1861, p. 186.

‡ Monographisk. Frems. Slægten Hippolytes Nordiske Arter, 1842, p. 100.

*abdominalis*, Kröyer, and *Pleurocrypta Galatheæ*, Hesse: the first was found under the carapace of *Doryphorus Gordoni*; the second under the abdomen of *Hippolyte securifrons*, Norman, and *H. pusiola*, Kröyer; and the *Pleurocrypta* was buried under the carapace of *Galathea intermedia*, Kröyer (=*G. dispersa*, Bate).

Ostracoda were obtained in extraordinary abundance, and included no less than sixty-five species. This number will, perhaps, be the more appreciated if I refer to the fact that the total number of forms of this order of the Crustacea described in 'Baird's History of British Entomostraca' only amounts to nineteen. Mr. G. S. Brady, who is engaged in preparing a monograph of these bivalve Crustacea, will present a separate report on the species met with; but I may here mention that thirty-seven are either wholly new to science, or, what is still more interesting, species previously known as Tertiary and post-Tertiary Fossils, and now for the first time met with in a recent state, or such as have been described by Norwegian naturalists from the Scandinavian seas.

A number of Copepoda recently described by Claus, were also met with. These include many genera which were previously unrecognized in our fauna:—the genus *Dactylopus*, represented by *tisboides*, *Strœmii*, *tenuicornis*, *cinctus*, and *brevicornis*; *Thalestris*, embracing *mysis*, *Helgolandica*, *harpacticoides*, and *longimana*; *Longipedia coronata* (a very curious and interesting form), *Eupelte gracilis*, *Cleta serrata*, and *Porcellidium fimbriatum* and *dentatum*. At Tobermory was discovered *Dyspontius striatus*, Thorell, a very remarkable genus with an enormously developed proboscis, which is almost equal in length to the rest of the animal.

A small freshwater loch near Stornoway contained, among other species, *Drepanothrix hamata*, G. O. Sars, a genus allied to *Macrothrix*, which may be at once distinguished from all allies by the presence of a largely developed spine in the middle of the dorsal margin of the carapace. It is now first announced as British, but has been previously taken by myself in Darden Loch, Northumberland, and by Mr. G. S. Brady in St. Mary's Loch, Selkirkshire.

The Echinoderms number thirty-four species. In addition to the common *Antedon rosaceus*, Linck, *Antedon Celticus* of Barrett was procured in deep water, both in the Minch and in Sleat Sound. This very fine species was previously only known to us from the two type specimens dredged by Messrs. MacAndrew and Barrett ten years ago in the Sound of Skye, and described in the 'Annals of Natural History'*. It is the largest member of the genus found in our seas, and is distinguished at a glance from *rosaceus*, *Milleri*, and *Sarsii* by the great length of the slender dorsal filaments, and also by the vertical position which the arms assume. In this peculiarity it resembles *Antedon Eschrichtii*, but differs from the other English species, in which the arms are always carried horizontally, or nearly so, and are incapable of being brought into contact with each other throughout their entire length. Only a few specimens were met with in Sleat Sound, and these were associated with *A. rosaceus*. In the Minch *A. Celticus* occurred gregariously, living in about sixty fathoms, in company with another rare British Echinoderm, *Holothuria intestinalis*, Ascanius. The only previously known British example of this species was procured many years ago by Professor Forbes

* *Comatula Woodwardii*, Barrett (Ann. Nat. Hist. 2nd series, vol. xix. p. 33, pl. 7. fig. 1), *Comatula Celtica*, Barrett (Ann. Nat. Hist. 2nd series, vol. xx. p. 44), *Antedon Celticus*, Norman (Ann. Nat. Hist. 3rd series, vol. xv. p. 104).

† Trans. Roy. Soc. Edinb. vol. xx. p. 309, pl. 9. fig. 1.

near the same spot; and as his figure and description† were scarcely sufficient for positive identification, the rediscovery of this Holothurian is important. As among the rarer of the other Echinodermata which were obtained may be mentioned *Psolus phantapus*, *Thyone fusus*, and *raphanus*, *Thyonidium commune* young (?), and *hyalinum*, *Cucumaria lactea*, *fusiformis*, and *Hyndmanni*, *Brissopsis lyrifera*, *Asterias hispida*, *Porania pulvillus*, *Ophiura affinis*, and *Amphiura Ballii*, *filiformis*, and *Chiajii*.

The Polyzoa include sixty-six species. In the Appendix will be found descriptions of many new forms:—a *Scrupocellaria* differing from *S. scruposa* in having larger cells, which do not bear any spines, in the proportionately larger vibracular capsules, and in the form of the mandible of the avicularium, which is blunter and shorter; a *Lepralia*, allied to the incrusting *Lepralia*-like state of *Eschara Landsborovii*; another remarkable on account of its much elevated collar-like peristome; a new *Eschara*, and an *Alecto* allied to *A. dilatans*. There is also an undescribed *Alcyonidium*: but the species of this genus are very difficult; and not having examined the present form in a living state, I have not attempted to define it. One or two small fragments of *Brettia pellucida*, Dyster, give a second locality for this Polyzoan, at a considerable distance from Tenby, where the type was found. Several rare northern Polyzoa, which had not previously occurred to the south of Shetland, are now traced southwards to the Minch—*Caberea Ellisii*, Fleming, *Lepralia polita*, Norman, *Lepralia laqueata*, Norman, *Idmonea Atlantica*, Forbes, *Hornera borealis*, Busk, &c.; and on the other hand we were greatly surprised by the well-known *Eschara foliacea* turning up in this northern locality, since it is an essentially southern species, which has not previously, I believe, been noticed to the north of Cape Clear.

Turning to the Actinozoa, the neighbourhood of Skye is the well-known habitat of *Pavonaria quadrangularis*, although the only place which produced it during the recent dredging was Loch Alsh. The rediscovery of *Rhizoxenia agglomerata*, Forbes*—although a mere fragment was obtained—is well worthy of special mention; but perhaps the most interesting of all the results of the expedition is the occurrence of a second species of *Pennatula* in our seas, which will be described by Mr. Alder under the name of *Pennatula mollis*.

The Hydrozoa are not numerous, amounting to only thirty-two species. *Sertularia alata*, Hincks, and *Calicella fastigiata*, Alder, had up to the present time been regarded as peculiar to Shetland; the little *Sertularia fusiformis*, Hincks, and the pretty *Plumularia tubulifera*, Hincks, not known previously on the Scotch coast, have now their range considerably extended northwards; and in the Appendix there are characters of two *Halecia*, new to science, one of which, *Halecium geniculatum*, is remarkable on account of its flexuous hydrosoma, which is bent alternately right and left between the hydrothecæ, and on account of the great length of the simple tubular hydrothecæ; the other, *Halecium sessile*, may be distinguished by its very small and perfectly sessile hydrothecæ, and by the very large non-retractile polypites.

The Sponges have not as yet been determined. It is, however, worthy of mention that three species peculiarly characteristic of the Haaf of the Shetland seas were living in the Minch, enjoying the companionship of many other of their northern friends. These species were *Tethea cranium*, Müller, *Isodictya infundibuliformis*, Linn., and *Phakellia ventilabrum*, Linn.

Appended will be found a catalogue of all the species found, descriptions

* *Sarcodictyon agglomerata*, Forbes, Trans. Roy. Soc. Edin. vol. xx. p. 309, pl. 9. fig. 3.

of such as are new to science, and a list of all those which are now for the first time recorded as living in our seas, with references to the several authors by whom they have been described.

*Crustacea.*

Stenorhynchus longirostris, *Fabr.*
Inachus Dorsettensis, *Penn.*
—— leptochira, *Leach.*
Hyas coarctata, *Leach.*
Eurynome aspera, *Penn.*
Xantho florida, *Leach.*
—— rivulosa, *Risso.*
Cancer pagurus, *Linn.*
Carcinus mænas, *Linn.*
Portunus puber, *Linn.*
—— depurator, *Linn.*
—— holsatus, *Fabr.*
—— pusillus, *Leach.*
Ebalia tuberosa, *Penn.*
—— Cranchii, *Leach.*
Atelecyclus septemdentatus, *Mont.*
Pagurus Bernhardus, *Linn.*
—— Prideauxii, *Leach.*
—— pubescens, *Kröyer.*
—— lævis, *Thomp.*
Porcellana platycheles, *Penn.*
—— longicornis, *Linn.*
Galathea squamifera, *Leach.*
—— intermedia, *Kröyer.*
—— Andrewsii, *Kin.*
Munida Bamffia, *Penn.*
Crangon vulgaris, *Linn.*
—— Allmani, *Kin.*
—— sculptus, *Bell.*
—— nanus, *Kröyer.*
—— serratus, *Norman* (= echinulatus, *Sars*).
—— spinosus, *Leach.*
Hippolyte varians, *Leach.*
—— pusiola, *Kröyer.*
—— securifrons, *Norman.*
—— cultellata, *Norman*, n. sp.
—— pandaliformis, *Bell.*
Pandalus annulicornis, *Leach.*
—— brevirostris, *Rathke.*
Doryphorus Gordoni, *Bate.*
Mysis flexuosa, *Müller.*
—— vulgaris, *Thomp.*
Diastylis bispinosa, *Say* (= D. bicornis, *Bate*).
—— lamellata, *Norman*, n. sp.
Eudorella * emarginata, *Kröyer* (= Cyrianassa ciliata, *Norman*, ♂).
Iphithoë serrata, *Norman*, n. sp.
Talitrus locusta, *Linn.*
Orchestia littorea, *Mont.*
Montagua marina, *Bate.*
Lysianassa Costæ, *M.-Edw.*
—— Audouiniana, *Bate.*
Anonyx Holböllii, *Kröyer* (= A. denticulatus, *Bate*).
Anonyx gulosus, *Kröyer* (=A. Holböllii, *Bate*).
—— longipes, *Bate.*
—— melanophthalmus, *Norman*, n. sp.
Euonyx chelatus, *Norman*, nov. gen. et sp.
Callisoma crenata, *Bate.*
Nicippe tumida, *Bruz.*
Ampelisca æquicornis, *Bruz.*
—— carinata, *Bruz.*
—— tenuicornis, *Lillj.*
—— macrocephala, *Lillj.*
Haploops tubicola, *Lillj.*
Monoculodes carinatus, *Bate.*
Œdiceros parvimanus, *Bate & West.*
Phoxus plumosus, *Holböll.*
—— Holböllii, *Kröyer.*
Urothoë marina, *Bate.*
—— elegans, *Bate.*
Acanthonotus Owenii, *Bate.*
Dexamine spinosa, *Mont.*
—— tenuicornis, *Rathke.*
—— Vedlomensis, *Bate & West.*
Atylus bispinosus, *Bate.*
Calliope Fingalli, *Bate & West.*
Eusirus Helvetii, *Bate.*
Leucothoë articulosa, *Mont.*
Aora gracilis, *Bate.*
Microdeuteropus anomalus, *Rathke*, ♂ & ♀.
—— Websterii, *Bate.*
—— versiculatus, *Bate*, ♂ & ♀.
Microprotopus maculatus, *Norman*, nov. gen. et sp.
Protomedeia Whitei, *Bate.*
Melita proxima, *Bate.*
Mæra Loveni, *Bruz.*
Eriopis elongata, *Bruz.*
Eurystheus erythrophthalmus, *Lillj.*
Gammarus marinus, *Leach.*
—— locusta, *Linn.*
Megamæra longimana, *Leach* } ♂ & ♀.
—— Othonis, *M.-Edw.* }
Amphithoë rubricata, *Mont.*
—— littorina, *Bate.*
Cerapus difformis, *M.-Edw.*
Arcturus longicornis, *Sow.*
Gyge Hippolytes, *Kröyer.*
Phryxus abdominalis, *Kröyer.*
Pleurocrypta Galatheæ, *Hesse.*
Jæra albifrons, *Leach.*
Oniscoda maculosa, *Leach.*
Idotea tricuspidata, *Desm.*
—— emarginata, *Fabr.*
Sphæroma Prideauxiana, *Leach.*
Cymodocea (?) truncata, *Leach.*
Cirolana cylindracea, *Mont.*
Nebalia bipes, *Fabr.*

* The name Eudorella is here proposed as a substitute for Eudora of Bate, the latter name having long been employed by Péron and Lesueur for a genus of Hydrozoa.

Paracypris polita, *Sars.*
Pontocypris mytiloides, *Norman* (=P. serrulata, *G. O. Sars*).
—— acupunctata, *Brady*, n. sp.
—— trigonella, *Sars.*
Bairdia obtusata, *Sars.*
—— complanata, *Brady*, n. sp.
—— inflata, *Norman.*
Cythere viridis, *Müller.*
—— convexa, *Baird.*
—— albomaculata, *Baird.*
—— lutea, *Müller.*
—— badia, *Norman.*
—— tenera, *Brady*, n. sp.
—— villosa, *Sars.*
—— concinna, *Jones.*
—— angulata, *Sars.*
—— limicola, *Norman.*
—— Finmarchica, *Sars.*
—— cuneiformis, *Brady.*
—— quadridentata, *Baird.*
—— emaciata, *Brady*, n. sp.
—— tuberculata, *Sars.*
—— Dunelmensis, *Norman.*
—— antiquata, *Baird.*
—— Jonesii, *Baird.*
Cytheridea punctillata, *Brady.*
—— papillosa, *Bosquet.*
—— dentata, *Sars.*
—— ? subflavescens, *Brady*, n. sp.
—— elongata, *Brady* (=C. angustata, *Baird*).
Cytheropsis declivis, *Norman.*
Ilyobates prætexta, *Sars.*
Loxoconcha tamarindus, *Jones* (=C. lævata, *Norman*).
—— impressa, *Baird.*
—— guttata, *Norman.*
Xestoleberis aurantia, *Baird.*
—— depressa, *Sars.*
Cytherura gibba, *Müller.*
—— nigrescens, *Baird.*
—— acuticostata, *Sars.*
—— angulata, *Brady*, n. sp.
—— producta, *Brady*, n. sp.
—— undata, *Sars.*
—— cellulosa, *Norman.*
—— clathrata, *Sars.*
Cytheropteron nodosum, *Brady*, n. sp.
—— punctatum, *Brady*, n. sp.
—— ? multiforum, *Norman.*
Bathocythere simplex, *Norman.*
—— constricta (?), *Sars.*
Pseudocythere caudata, *Sars.*
Sclerochilus contortus, *Norman.*
Paradoxostoma variabile, *Baird.*
—— abbreviatum, *Sars.*
—— ensiforme, *Brady*, n. sp.
—— flexuosum, *Brady*, n. sp.
—— Normani, *Brady*, n. sp.
—— Hybernicum, *Brady*, n. sp.
—— pulchellum, *Sars.*
Bradycinetus McAndrei, *Baird.*
—— teres, *Norman.*
Cylindroleberis Mariæ, *Baird.*
Philomedes interpunctus, *Baird* (=P. longicornis, *Lilljeborg*).
Polycope orbicularis, *Sars.*
Cytherella Scotica, *Brady*, n. sp.
Thalestris mysis, *Claus.*
—— Helgolandica, *Claus.*
—— harpactoides, *Claus.*
—— longimana, *Claus.*
Dactylopus tisboides, *Claus.*
—— Strœmii, *Baird.*
—— tenuicornis, *Claus.*
—— cinctus, *Claus.*
—— brevicornis, *Claus.*
Harpacticus chelifer, *Müller.*
Longipedia coronata, *Claus.*
Eupelte gracilis, *Claus.*
Westwoodilla nobilis, *Baird.*
Cleta serrata, *Claus.*
Tisbe furcata, *Baird.*
Porcellidium fimbriatum, *Claus*
—— dentatum, *Claus.*
Alteutha bopyroides, *Claus.*
Dias longiremis, *Lilljeborg.*
Cetochilus septentrionalis, *Goodsir.*
Anomalocera Patersonii, *Templeton.*
Dyspontius striatus, *Thorell.*
Balanus porcatus, *Da Costa.*
Verruca Strœmia, *Müller.*
Sacculina carcini, *Thomp.*
Pycnogonum littorale, *Strom.*

## *Freshwater Species.*

Daphnella brachyura, *Lièvin.*
Daphnia longispina, *Müller.*
Drepanothrix hamata, *G. O. Sars.*
Polyphemus pediculus, *Linn.*
Eurycercus lamellatus, *Müller.*
Chydorus sphæricus, *Müller.*
—— globosus, *Baird.*
Camptocercus macrourus, *Müller.*
Acroperus harpæ, *Baird.*
Alona quadrangularis, *Müller.*
Alonella elongata, *G. O. Sars.*
Peracantha truncata, *Müller.*
Cypris ovum, *Jurine* (=C. minuta, *Baird*).
Diaptomus Westwoodii, *Lubbock.*
Cyclops serrulatus, *Fischer.*

## *Echinodermata.*

Holothuria intestinalis, *Ascanius.*
Psolus phantapus, *Linn.*
Thyone fusus, *Müller.*
—— raphanus, *Dub. & Kor.*
Thyonidium commune, *Forbes & Goods.* (?)
Thyonidium hyalinum, *Forbes.*
Cucumaria lactea, *Forbes & Goodsir.*
—— fusiformis, *Forbes & Goodsir* (=C. elongata, *Dub. & Kor.*).
—— Hyndmanni, *Thomp.*

Echinocardium ovatum, *Leske.*
Brissopsis lyrifera, *Forbes.*
Echinocyamus pusillus, *Müller.*
Echinus esculentus, *Linn.*
—— Flemingii, *Ball.*
—— miliaris, *Leske.*
Asterias rubens, *Linn.*
—— hispida, *Penn.*
Stichaster roseus, *Müller.*
Cribrella sanguinolenta, *Müller.*
Solaster papposus, *Linn.*
Palmipes placenta, *Penn.*
Porania pulvillus, *Müller.*
Astropecten irregularis, *Penn.*
Ophiura lacertosa, *Penn.*
—— albida, *Forbes.*
—— affinis, *Lütken* (= O. Normani, *Hodge*).
Ophiopholis aculeata, *Müller.*
Ophiocoma nigra, *Müller.*
Amphiura Ballii, *Thomp.*
—— elegans, *Leach.*
—— filiformis, *Müller.*
—— Chiajii, *Forbes.*
Antedon rosaceus, *Linck.*
—— Celticus, *Barrett.*

## *Polyzoa.*

Brettia pellucida, *Dyster.*
Salicornaria farciminoides, *Johnst.*
Scrupocellaria scrupea, *Busk.*
—— scruposa, *Linn.*
—— inermis, *Norman*, n. sp.
Hippothoa catenularia, *Johnst.*
—— divaricata, *Lamx.*
Ætea recta, *Hincks.*
Gemellaria loriculata, *Linn.*
Caberea Ellisii, *Fleming.*
Bugula avicularia, *Pallas.*
—— Murrayana, *Bean.*
Flustra foliacea, *Linn.*
Flustrella hispida, *Fabr.*
Membranipora membranacea, *Linn.*
—— pilosa, *Pall.*
—— coriacea, *Esper.*
—— imbellis, *Hincks.*
—— Pouilletii, *Aud.*
—— Flemingii, *Busk.*
—— lineata, *Linn.*
Lepralia crystallina, *Norman*, n. sp.
—— auriculata, *Hass.*
—— concinna, *Busk.*
—— trispinosa, *Johnst.*
—— coccinea, *Abildg.*
—— linearis, *Hass.*
—— ciliata, *Pall.*
—— Hyndmanni, *Johnst.*
—— variolosa, *Johnst.*
—— laqueata, *Norman.*
—— nitida, *Fabr.*
—— Peachii, *Johnst.*
Lepralia ventricosa, *Hass.*
—— polita, *Norman.*
—— innominata, *Couch.*
—— punctata, *Hass.*
—— Pallasiana, *Moll.*
—— simplex, *Johnst.*
—— Malusii, *Aud.*
—— hyalina, *Linn.*
—— ansata, *Johnst.*
—— unicornis, *Johnst.*
—— collaris, *Norman*, n. sp.
Cellepora pumicosa, *Linn.*
—— ramulosa, *Linn.*
—— dichotoma, *Hincks.*
—— cervicornis, *Fleming.*
—— Hassallii, *Johnst.*
Palmicellaria elegans, *Alder.*
Eschara foliacea, *Ellis & Sol.*
—— Skenei, *Ellis & Sol.*
—— quincuncialis, *Norman*, n. sp.
Retipora Beaniania, *King.*
Patinella patina, *Linn.*
Heteroporella hispida, *Fleming.*
Diastopora obelia, *Fleming.*
Tubulipora serpens, *Linn.*
Idmonea Atlantica, *Forbes.*
Hornera borealis, *Busk.*
Alecto granulata, *M.-Edw.*
—— major, *Johnst.*
—— compacta, *Norman*, n. sp.
Crisia eburnea, *Linn.*
Alcyonidium ——, n. sp.
Arachnidia hippothooides, *Hincks.*

## *Actinozoa.*

Adamsia palliata, *Forbes.*
Actinia mesembryanthemum, *Ellis.*
Tealia crassicornis, *Müll.*
Caryophyllea Smithii, *Fleming.*
Pennatula mollis, *Alder*, n. sp.
Virgularia mirabilis, *Linn.*
Pavonaria quadrangularis, *Pall.*
Alcyonium digitatum, *Linn.*
Rhizoxenia catenata, *Forbes.*
—— agglomerata, *Forbes.*

## *Hydrozoa.*

Hydractinia echinata, *Fleming.*
Eudendrium —— ?
Perigonimus (sessilis, *Wright* ?).
Tubularia indivisa, *Linn.*
Campanularia Johnstoni, *Alder.*
—— Hincksii, *Alder.*
—— verticillata, *Linn.*
Obelia geniculata, *Linn.*
Calicella fastigiata, *Alder.*
Lafoëa dumosa, *Linn.*
Reticularia serpens, *Hass.*
Coppinia arcta, *Dalyell.*
Halecium geniculatum, *Norman*, n. sp.
—— sessile, *Norman*, n. sp.

Sertularia polyzonias, *Linn.*
—— tenella, *Alder.*
—— alata, *Hincks.*
—— pinaster, *Ell. & Sol.* } ♂ & ♀.
—— Margareta, *Hass.* }
—— fallax, *Johnst.*
—— abietina, *Linn.*
—— filicula, *Ell. & Sol.*
—— operculata, *Linn.*

Sertularia argentea, *Ell. & Sol.*
—— fusiformis, *Hincks.*
Antennularia antennina, *Linn.*
Plumularia falcata, *Linn.*
—— tubulifera, *Hincks.*
—— myriophyllum, *Linn.*
—— pinnata, *Linn.*
—— setacea, *Ellis.*
—— frutescens, *Ell. & Sol.*

Class CRUSTACEA.

*Hippolyte cultellata*, Norman, n. sp.

Carapace gibbous, anteriorly keeled and toothed. Rostrum about equal to the carapace in length, not twice as long as the eye, and shorter than the antennal scale, nearly horizontal, cultellate, above with five nearly equal-sized teeth, posterior to which are two others on the carapace; below with four teeth, all anterior to the fifth tooth of the upper margin. Front margin of carapace with three pairs of spines; the first large, above the eye; the second below the eye; the third small, at the infero-anteal angle. Third abdominal segment somewhat gibbous, but not dorsally produced; fourth with a small spine on the lateral margin; fifth with the infero-posteal angle produced into a conspicuous spine. Second gnathopods reaching the end of the antennal scale. First pereiopods reaching the middle of the last joint of second gnathopods; second pereiopods with seven-jointed wrist, left as long as right, longer than second gnathopods. Telson furnished with nine pairs of lateral spines, and terminated in thirteen spines, of which the outermost pair but one are the longest, and the nine spines between this pair are subequal in length, and ciliated on both margins. Colour pink, beautifully spotted with crimson. Length, exclusive of antennæ, rather more than an inch and a half. One specimen dredged in the Minch.

*Diastylis lamellata*, Norman, n. sp.

*Female.*—Cephalothorax very large, deep and wide in the gravid female, viewed laterally almost subglobular, with the dorsal margin boldly arched; viewed dorsally, remarkably wide, ovate, greatest breadth in the centre. Carapace having a short, blunt, horizontal rostrum; sculptured with three oblique raised lamellæ, the hindmost just at the border of the carapace, and continued round the dorsal margin, the two others are equal distances apart, not continued across the back; on either side of the central dorsal line is a series of what appear in spirit-preserved specimens to be lucid spots; possibly, however, they may be coloured markings in the living animal. The second and third cephalothoracic segments raised into dorsal lamellæ of corresponding character to those of the carapace; the anterior dorsal margin, sixth segment, and the posterior margin of the preceding one denticulately serrate. Superior antennæ having the three joints of the peduncle subequal in length, the internal and longer filament shorter than the last joint of the peduncle. The first pereiopods have the basal joint narrow and much bent, its inferior margin fringed with plumose setæ and furnished with a row of spines; penultimate joint very long and slender, equalling in length the three preceding articulations and as long as the basal joint; terminal joint half the length of the penultimate; palp two-thirds as long as the basal joint, not furnished with any spines. Second pereiopods having the superior margin of the basal joint furnished with spines, the last and the antepenultimate joints subequal, and more than twice as long as the penultimate; palp reaching beyond the third

joint, its basal portion not spined. Telson twice as long as the preceding segment, suddenly contracted near the base, the last part narrow and linear, having four pair of lateral and two much larger terminal spines. Peduncle of uropods narrow and slender, as long as the telson, and about one-sixth longer than the rami, furnished with about eight spines on the inner margin; interior ramus slightly longer than exterior, having nine spines on the inner margin (6 on first, 2 on second, and 1 on third joint), and a long terminal spine; exterior ramus terminating in three setæ, of which the central is the longest (the interior not quite terminal), and having four spines, and one other seta on the outer margin, but none on the inner.

Length 3 lines. Dredged in Sleat Sound, and also off Tynemouth, Northumberland. Nearly allied to *Diastylis biplicata*, G. O. Sars, but apparently distinct.

*Iphithoë serrata*, Norman, n. sp.

Animal greatly elongated and very slender. Cephalothorax shallow and much compressed, dorsally keeled throughout, equal in length to six abdominal segments, and twice and a half as long as deep; rostrum long, slightly bent upwards, apex obliquely truncate, crenated and ciliated; latero-anterior margin with only two or three minute spines; a deep sinus on the lower portion of the front margin; dorsal line with a crest of spines (13–20), which sometimes extend almost to the posterior margin of the carapace, sometimes are obsolete on the hinder portion; the spines gradually increase in size forwards, and the two or three anterior spines are more widely separated from each other than the rest. Superior antennæ shorter than the rostrum, having the last joint of the peduncle longer than either of the preceding, and four times as long as the very short two-jointed internal filament; external filament very minute, one-jointed. Second gnathopods having the lower margin of the basal joint denticulate, and its lobe reaching to the middle of the third joint; lobe of third joint smaller than is usual in the genus, but bearing several long plumose setæ, the most distal the longest. First pereiopods having both margins of basal joint denticulated; extended beyond the rostrum, which reaches the middle of the penultimate joint; last and antepenultimate joints subequal, and about one-third shorter than the penultimate. Second pereiopods five-jointed, having a large spine at the termination of the second and third joints; last joint as long as the two preceding. Telson semicircular, terminating in spine-like points and two setæ. Uropods strongly formed; peduncle of moderate length (not twice as long as last abdominal segment), furnished with 12–14 long slender spines on the inner margin; rami shorter than the peduncle, and subequal; interior with basal joint swollen, having five spines on the middle margin, the distal one very large; second joint having twelve spines on the inner margin and apex, and three setæ on the outer margin; all the spines of the rami are ciliated, and the two terminal spines are developed to such a length that they are intermediate in form between spines and setæ; outer ramus flattened, having about twelve plumose setæ on the inner margin and round the apex. Length about five lines.

Female specimens dredged in Sleat Sound.

*Anonyx melanophthalmus*, Norman, n. sp.

Eye black. Superior antennæ having the first joint of the peduncle nearly as long as the two succeeding joints taken together, filament with nine articulations; appendage five-jointed, the first very long, equalling the first long joint of the filament. Inferior antennæ having last two joints of peduncle

furnished with tufts of hair on the upperside; filament short, equal in length to last two joints of peduncle, seven-jointed. First gnathopods short; wrist excessively short, forming a little projecting hair-tipped lobe on the posterior margin, and much shorter than preceding joint (meros); hand oblong, as long as the wrist and meros taken together, with only two fine setæ on the anterior, and a few spine-like setæ on the posterior margin, slightly narrowed towards the palm, which is not at all oblique; nail very large, having one or two fine setæ on the upper margin. Second gnathapods with wrist and meros subequal, and each longer than the hand, meros having posterior and wrist anterior margin covered with fine down-like setæ; pad of wrist finely scaled; hand much narrower than the wrist, having both margins beset with fine downy setæ; terminal brush of hair not dense; nail well developed, and infero-posteal angle of hand produced so as to form with the nail a little chela. Last pereiopods not having any of the joints below the basis posteriorly produced. Branches of last uropods slightly longer than the peduncle, outer terminating in three spines and having two or three small spines on the margin; inner terminating in a single spine, and having only one very fine seta on each margin. Telson having a wide but shallow cleft, which does not extend more than one-third of its length; each portion is terminated by a single spine, and there are also two pairs of spines on the upper surface. Posterior angles of abdominal segments rounded and not serrate. Fourth abdominal segment with a dorsal sinus.

Dredged in Sleat Sound.

*Euonyx*, Norman, nov. gen.

Differing from *Anonyx* in having the first gnathopods chelate, and the second stronger than the first, subchelate, nail large and strong. Posterior uropods two-branched. Telson cleft.

*Euonyx chelatus*, Norman, n. sp.

Superior antennæ bent directly downwards; first joint of peduncle very large, concave above (thus giving the front of the head, the antennæ being bent downwards, an emarginate appearance); second and third joints very short, and much narrower than the first; filament ten-jointed; appendage six-jointed; reaching to the end of the third joint of the filament. Inferior antennæ having the last two joints of the peduncle subequal, not furnished with any spines or hairs; filament twenty-jointed, not twice as long as the peduncle. First gnathopods having hand and wrist about equal to each other, long, narrow, parallel-sided, nearly naked, having only very few setæ; inferior distal angle of hand greatly produced, so as to form in conjunction with the nail a slender horizontal chelate claw; nail large, strong, furnished with two or three bristles on the upper margin near the point. Second gnathopods more strongly developed than the first, having the wrist furnished with tufts of hair on the posterior margin; hand shorter than wrist, having several rows of long setæ on anterior, and two similar rows on the posterior margin; palm oblique, well-defined, concave; nail large, strongly curved, simple. Pereiopods very stout and strong, having the basis largely developed and extending downwards to the middle of the meros; posterior margin of meros also largely developed outwards and downwards into a process which, in the posterior, extends beyond the carpus; the whole of the anterior side of the legs is beset with numerous strong spines; the nail is large, very strong, and has a cilium on the inner side near the extremity. Rami of last uropods flattened and nearly twice as long as peduncle, margins plain; inner ramus

one-jointed, outer terminated in a flattened spine. Telson divided almost to the base, but the two portions are in contact with each other to the apex, margins smooth. Fourth abdominal segment has a deep sinus on the anterior portion of the dorsal margin, and behind this a large hump-like elevation. Animal pure white. Dredged parasitic on *Echinus esculentus*, L., in Sleat Sound.

*Microprotopus*, Norman, nov. gen.

Antennæ with secondary appendage. First gnathopods subchelate. Second gnathopods larger than first, subchelate, greatly developed in ♂, much smaller in ♀. Uropods terminating in simple spines, those of last pair with a single ramus. Telson tubular.

*Microprotopus maculatus*, Norman, n. sp.

*Male.*—Eye small, round, crimson, situated on a lobe between the bases of the two pairs of antennæ. Antennæ subequal, superior having peduncle reaching a little beyond the penultimate joint of the peduncle of the inferior antennæ; basal joint stouter than, but equal in length to, the second; third joint shorter and more slender than the preceding; appendage minute, two-jointed, not so long as first joint of filament, which consists of nine or ten articulations, and is of about equal length with the peduncle. Inferior antennæ stronger than the superior, and, as well as the superior, furnished with scattered hairs, but no spines. Mandible with a three-jointed palp. First gnathopods having the hand of equal length to the wrist, but broader, widening from the base to the extremity, palm oblique, concave; nail well developed, simple, extending rather beyond the palm. Second gnathopods having the wrist very short, hand greatly developed, as long as, or even longer than the whole of the rest of the leg, oblong, palm whole length of hand, slightly concave, with a tooth-like process (wanting in the young) at the base, and two large teeth on the distal third; finger large, strong, curved, fully as long as the hand; the inner margin under a high power of the microscope is seen to be finely crenated, or, rather, rasped like a file. Uropods furnished with a few simple spines; the penultimate pair extending beyond the last, which have only one branch; this branch is rather longer than the peduncle, and is furnished with two or three spines on the inner margin, and terminates in two spines and a cilium. Telson tubular; apex truncate, slightly emarginate, and having one or two hairs at the angles.

In the female the first gnathopods are of nearly the same form as those of the male, but the hand is rather narrower: the second gnathopods are wholly different; the wrist and two preceding joints are very short, the former, however, is the more developed, and assumes a caliculate form at its termination from its having a projecting seta-tipped lobe both in front and behind; hand subquadrate, narrower than the wrist, with a row of long scattered setæ down the centre; palm slightly oblique, concave, with a few fine fringing setæ, and a single spine at the angle; nail as long as the palm, strong. Colour yellowish, more or less covered with umber-brown spots; these spots are seen under the microscope to be dendritic; they often form bands across the segments, or at times so coalesce as to make the whole animal appear of a brown colour. Length two lines. Found at Tobermory in Mull, among Laminariæ.

Class Polyzoa.

*Scrupocellaria inermis*, Norman, n. sp.

Cells regularly ovate, wholly unspined, and not furnished with any operculum or suboral avicularia; mandible of lateral avicularia very short and

blunt; ovicell globular, smooth, inclining inwards; vibracular capsules of moderate size, erect, bilobed; vibracula long, arising from between the lobes of the capsules. Height half an inch. Dredged in deep water in the Minch, also at Shetland. Differs from *S. scruposa* in having the cells larger, not furnished with spines, and in the vibracular capsules, which are proportionately large, and the mandible of the avicularia being shorter and blunter.

*Eschara quincuncialis*, Norman, n. sp.

Polyzoary white, smooth, polished, cylindrical. Cells distant, in linear series, regularly arranged in quincunx, swollen, mammiform. Apertures keyhole-shaped, rounded above, with a small sinus below, immediately beneath which a small inconspicuous avicularium is sometimes present. Ovicell small, with 1–4 round perforations.

The specimen described is apparently a fragment, and is not more than a quarter of an inch long. It is, however, manifestly distinct from all the *Escharæ* with which we were previously acquainted. Dredged in deep water in the Minch.

*Lepralia collaris*, Norman, n. sp.

Cells small, crowded, linearly arranged, not in quincunx, granular, not punctured round the margin; mouth arch-formed, rounded above, truncate below; peristome greatly elevated into a frill-like plate which surrounds the sides and lower margin of the mouth, within which there is no denticle; ovicell globular, of moderate size, punctate.

In small patches on old shells and stones from the Minch, coast of Antrim, Guernsey, and Shetland. It will be evident from the foregoing list of localities that this species is widely distributed on our coasts. It has been hitherto mistaken (by Mr. Busk, Mr. Alder, and myself) for *L. eximia*, Hincks, in common with which species it has the peculiar collar-formed peristome; but having recently had an opportunity of examining Mr. Hincks's typical and only known specimen of *L. eximia*, I found it to be a wholly different form from that which is now described.

*Lepralia crystallina*, Norman, n. sp.

Cells short, obovate, of moderate size, and moderately tumid, not regularly arranged, nor separated from each other by raised lines, nor areolated at the margin; white, crystalline, punctate, punctures round, few, equally distributed on all parts of the cell; mouth triangular, lateral walls much raised, margined above with five spines (rarely present), a small avicularium at the lower angle of the mouth, with short rounded mandible directed downwards; a bifid tooth-like process within the mouth; ovicell globular, crystalline, punctate.

On shell and stone in very small patches. The Minch and Shetland in deep water. Nearly allied to *L. Landsborovii*, as compared with which the cells are smaller, shorter, more convex, less regularly disposed, not separated from each other by distinct raised lines, more regularly punctate than is usual in *L. Landsborovii*, in which the punctures are often absent from the centre of the cell; the mouth also is more angular.

*Alecto compacta*, Norman, n. sp.

Polyzoary narrow at the base, thence rapidly widening and irregularly ramifying, branches wide and short, their terminations rounded; remarkably flat, and closely appressed to the shell. Cells very small, irregularly scattered and separated from each other, shortly tubular, scarcely raised above the

level of the polyzoary, all inclining towards distal extremity of branches, though bending slightly towards the side of the polyzoary to which they are nearest. Colour white. On stone and shell. The Minch and Shetland in deep water.

*A. compacta* approaches more nearly to *A. dilatans* than to the other described species, but is much smaller and more delicate in all its parts, and depressed flat to the surface instead of being raised in a swollen cushion-like manner. *A. dilatans* is usually tinged with violet, while *A. compacta* is always white, and approaches in many respects to a *Diastopora*.

## Class Hydrozoa.

### *Halecium geniculatum*, Norman, n. sp.

Hydrosoma slender, branching, the branches (in type specimen) all in the same plane; branchlets flexuous, bending alternately right and left between the hydrothecæ (as in *Laomedea geniculata*); one hydrotheca to each internode; the internode terminating immediately above the hydrotheca and marked by a single stricture, or more rarely two. Hydrothecæ diverging at about an angle of 45° from the cœnosarc, much elongated, simply tubular, fully two-thirds as long as the internodes of the cœnosarc, and 3–6 times as long as their own diameter; a constriction near the base, at the point where the more strongly developed chitine of the base of the hydrotheca is exchanged for a membrane of more delicate structure. Height an inch and a half. Dredged in deep water in the Minch.

### *Halecium sessile*, Norman, n. sp.

Hydrosoma slender, irregularly branching, branches not in the same plane; branchlets having alternate hydrothecæ, and a single constriction above each hydrotheca. Hydrothecæ very short and perfectly sessile, not rising at all separately from the hydrosoma, of the lateral projections of which they are mere openings, without being raised into any tube. Polypites large, not retractile, very narrow at the base, where they rise from the hydrotheca, thence gradually widening to near the summit, where they suddenly swell into a wide campanulate mouth surrounded by long and slender filiform tentacles; the polypites rise above the hydrotheca to a height (exclusive of tentacles) which is not less than five times its diameter, and far overtop the level of the succeeding hydrotheca. Height probably an inch and a half, though the fragments obtained are not more than half that length. Dredged in deep water in the Minch.

The following is a list of the species which are now for the first time recorded as members of the British Fauna.

Hippolyte cultellata, *Norman*, n. sp.
Diastylis lamellata, *Norman*, n. sp.
Iphithoë serrata, *Norman*, n. sp.
Anonyx melanophthalmus, *Norman*, n. sp.
Euonyx chelatus, *Norman*, nov. gen. et sp.
Ampelisca carinata, *Bruz.* *
—— tenuicornis, *Lillj.* †
—— macrocephala, *Lillj.* †
Microprotopus maculatus, *Norman*, nov. gen. et sp.
Mæra Lovéni, *Bruz.* *
Eriopis elongata, *Bruz.* *
Pleurocrypta Galatheæ, *Hesse?* ‡
Paracypris polita, *Sars* §.
Pontocypris acupunctata, *Brady*, n. sp.
—— trigonella, *Sars* §.
Bairdia obtusata, *Sars* §.
—— complanata, *Brady*, n. sp.
Cythere viridis, *Müller* ‖.
—— tenera, *Brady*, n. sp.

* Bidrag till kännedomen om Skandinaviens Amphipoda Gammaridea, 1859.
† Öfvers. af Kongl. Vetensk. Akad. Förhandl., 1855, pp. 123, 137.
‡ Annales des Sciences Naturelles, Cinquième Série, tom. iii. (1865) p. 226, pl. 4.
§ "Oversigt af Norges Marine Ostracoder," Vid.-Selsk. Forhand. 1865.
‖ Entomostraca, p. 64, tab. vii. figs. 1, 2 (and of Sars, but not of Lilljeborg).

Cythere villosa, *Sars* *.
—— concinna, *Jones* †.
—— angulata, *Sars* *.
—— Finmarchica, *Sars* *.
—— cuneiformis, *Brady*, n. sp.
—— emaciata, *Brady*, n. sp.
—— tuberculata, *Sars* *.
Cytheridia punctillata, *Brady* ‡.
—— dentata, *Sars* *.
—— ? subflavescens, *Brady*, n. sp.
Ilyobates prætexta, *Sars* *.
Xestoleberis depressa, *Sars* *.
Cytherura gibba, *Müller* §.
—— acuticostata, *Sars* *.
—— angulata, *Brady*, n. sp.
—— producta, *Brady*, n. sp.
—— undata, *Sars* *.
—— clathrata, *Sars* *.
Cytheropteron nodosum, *Brady*, n. sp.
—— punctatum, *Brady*, n. sp.
Bathocythere constricta (?) *Sars* *.
Pseudocythere caudata, *Sars* *.
Paradoxostoma abbreviatum, *Sars* *.
—— ensiforme, *Brady*, n. sp.
—— flexuosum, *Brady*, n. sp.
—— Normani, *Brady*, n. sp.
—— Hybernicum, *Brady*, n. sp.
—— pulchellum, *Sars* *.

Polycope orbicularis, *Sars* *.
Cytherella Scotica, *Brady*, n. sp.
Thalestris mysis, *Claus* ‖.
—— Helgolandica, *Claus* ‖.
—— harpacticoides, *Claus* ‖.
Dactylopus tisboides, *Claus* ‖.
—— tenuicornis, *Claus* ‖.
—— cinctus, *Claus* ¶.
—— brevicornis, *Claus* ¶.
Longipedia coronata, *Claus* ‖.
Eupelte gracilis, *Claus* ‖.
Cleta serrata, *Claus* ‖.
Porcellidium fimbriatum, *Claus* ‖.
—— dentatum, *Claus* **.
Dyspontius striatus, *Thorell* ††.
Drepanothrix hamata, *G. O. Sars* ‡‡.

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Scrupocellaria inermis, *Norman*, n. sp.
Lepralia crystallina, *Norman*, n. sp.
—— collaris, *Norman*, n. sp.
Eschara quincuncialis, *Norman*, n. sp.
Alecto compacta, *Norman*, n. sp.
Alcyonidium ——, n. sp.

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Pennatula mollis, *Alder*, n. sp.

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Halecium geniculatum, *Norman*, n. sp.
—— sessile, *Norman*, n. sp.

P.S.—It will be observed that the list of Ostracoda given in the foregoing Report differs from that of Mr. G. S. Brady. This arises from the fact that the Reporter has had an opportunity of revising the lists at a much later period (May 10, 1867), when further time had allowed a more complete examination to be made of the material collected. The present lists, in the drawing up of which he has been assisted by Mr. Brady, have thus been rendered more full and more correct.

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## *Notices of some Invertebrata, in connexion with the Report of* Mr. Gwyn Jeffreys *on Dredging among the Hebrides. By* Joshua Alder.

A Serpula lately dredged by Mr. Jeffreys in the Hebrides, on the fragment of an old shell, possesses some interest in a physiological point of view, on account of the peculiar character of its shell. It is slender and strongly carinated through the greater part of its length, not unlike the common *Serpula triquetra*, but rather more slender. Near the mouth, however, there is an oblong bulbous swelling of the same substance as the shell, but rather less compact and more brittle; this terminates in a double arch in front. On

* "Oversigt af Norges Marine Ostracoder," Vid.-Selsk. Forhand. 1865.
† Entomostraca of the Tertiary Formation, p. 29, pl. 4. fig. 7.
‡ Annals and Mag. Nat. Hist. 3rd series, vol. xvi. (1865), pl. 9. fig. 9–11.
§ Entomostraca, p. 24, pl. 7. fig. 10–12.
‖ Die frei lebenden Copepoden, 1863.
¶ Die Copepoden-Fauna von Nizza, 1866.
** Beiträge zur Kenntniss der Entomostraken, 1 Heft, Marburg, 1860, p. 8, tab. ii. figs. 19–22.
†† Bidrag till kännedomen on Krustaceer som lefva i arter af slägtat Ascidia, S. 1859.
‡‡ Om de i omegnen af Christiania forekommende Cladoceren, 1861, p. 14, and Andet Bidrag, 1862, p. 51.

examining its structure, we find that this bulbous portion consists of two cells, divided from each other by a thin wall of shell, and that the triangular tube of the general body is continued through its base, with the mouth of the tube opening generally immediately below it. In one instance, however, the tube is continued for a short distance in front of the swelling. Mr. Jeffreys suggests that this protuberance may be an egg-case, which I think is very probable, as there is a small external aperture in front of each partition, which apparently communicate with the tubular portion posteriorly. I am not aware that any similar structure has been before observed in the tubular Annelids; and I therefore now take the opportunity of bringing the circumstance under the notice of naturalists, in order that it may be investigated by those more immediately connected with the study of this department of zoology. The species appears to be a new one; but it is impossible to speak with certainty in the absence of the animal inhabitant of the tube. In one individual two of these protuberances have been formed, one behind the other.

PENNATULA MOLLIS, n. sp.

*Polypary* 4 or 5 inches long, of a brick-red colour, variegated with darker red streaks, slender, rather soft and flaccid. *Stem* slender, rounded, smooth, and very slightly bulbous at the base, occupying from one-third to half the length of the compound body. *Rhachis* smooth in front, except an undulating line of tubercles running at the base of the pinnæ on each side; the back of the rhachis has a smooth groove in the centre, on each side of which it is set with small pointed granules, smaller and less crowded than in *P. phosphorea*. *Pinnæ* compressed, flaccid, slightly fusiform, about half an inch long in the centre of the rhachis, but decreasing towards each end; these terminate in a rather obtuse point at the apex, and diminish gradually to minute processes below; they are placed a little further apart, are less triangular, and have a narrower base than those of *P. phosphorea*. *Polype-cells* cylindrical, set in a single row on the front margin of each pinna, and terminating as usual in eight denticles; they are rather shorter and less spiculose than in *P. phosphorea*, and number about twelve in each row of the longer pinnæ. This species has considerable resemblance to the *Pennatula phosphorea* of our coast, the differences between them, though well marked, being only comparative. It is larger, more slender, and much softer and more flaccid in all its parts than that species. This latter character arises principally from the fewer spicula in its composition, from which cause also it is of a paler and duller red, the colouring-matter being principally confined to the spicula. The pinnæ are not so crowded as in *P. phosphorea*, and are less firmly and broadly set on the rhachis, leaving a little more space in front.

It is probable that this may be Pallas's *Pennatula rubra*, var. *β*, of which he says, "Datur varietas, in oceano præsertim, longior, gracilior, pinnis angustioribus, magisque distantibus, caliculis pinnarum rarioribus et prominentioribus." There can be little doubt, however, that this species is distinct from the *P. rubra* of Pallas, which is the *P. phosphorea* of British authors, and probably also of Linné. The differences between them are as great as is usual in other species of this genus.

This is an interesting addition to our fauna, one species only of *Pennatula* having been previously known as British.

TUNICATA.

Ascidia mentula.
—— venosa.
Ascidia plebeia.
—— aspersa.

Ascidia depressa.
—— intestinalis.
—— parallelogramma.
Molgula arenosa.
Cynthia tessellata.
—— squamulosa, young.
—— echinata.
Cynthia tuberosa.
—— informis?
Cynthia violacea.
—— grossularia.
Clavellina lepadiformis.
Diazona Hebridica.
Parascidia Flemingii.
—— ——?
Didemnum gelatinosum.
Botryllus —— ?

NUDIBRANCHIATA.

Doris tuberculata.
—— Johnstoni.
Dendronotus arborescens.
Hero formosa.
Eolis —— ?

## *Report on the* Ostracoda *dredged amongst the Hebrides.*

*By* GEORGE S. BRADY.

*List of Species.*

Paracypris polita, *G. O. Sars.*
*Pontocypris mytiloides, *Norman.*
—— acupunctata, n. sp.
*Bairdia inflata, *Norman.*
—— obtusata, *G. O. Sars.*
—— complanata, n. sp.
*Cythere lutea, *Müller.*
*—— viridis, *Müller.*
*—— pellucida, *Baird.*
*—— badia, *Norman.*
*—— albomaculata, *Baird.*
*—— convexa, *Baird.*
*—— angustata, *Münster.*
—— subflavescens, n. sp.
*—— ventricosa, *G. O. Sars.*
*—— villosa, *G. O. Sars.*
—— Finmarchica, *G. O. Sars.*
*—— angulata, *G. O. Sars.*
*—— tuberculata, *G. O. Sars.*
*—— concinna, *Jones.*
—— quadridentata, *Baird.*
—— emaciata, n. sp.
*——limicola, *Norman.*
*—— Dunelmensis, *Norman.*
—— antiquata, *Baird.*
*—— Jonesii, *Baird.*
—— multifora, *Norman.*
—— complexa, n. sp.
*Cytheridea papillosa, *Bosquet.*
*—— punctillata, *Brady.*
*Cytheridea inermis, *G. O. Sars.*
*—— dentata, *G. O. Sars.*
*Cytheropsis declivis, *Norman.*
Ilyobates prætexta, *G. O. Sars.*
*Loxoconcha granulata, *G. O. Sars.*
—— impressa, *Baird.*
—— guttata, *Norman.*
*—— tamarindus, *Jones.*
*Xestoleberis depressa, *G. O. Sars.*
Cytherura nigrescens, *Baird.*
*—— undata, *G. O. Sars.*
—— humilis, n. sp.
*—— acuticostata, *G. O. Sars.*
*—— clathrata, *G. O. Sars.*
*Cytheropteron latissimum, *Norman.*
—— tricorne, *Bornemann.*
*Bythocythere simplex, *Norman.*
—— flexuosa, n. sp.
—— constricta, *G. O. Sars.*
Pseudocythere caudata, *G. O. Sars.*
*Sclerochilus contortus, *Norman.*
*Paradoxostoma variabile, *Baird.*
—— abbreviatum, *G. O. Sars.*
Cypridina teres, *Norman.*
—— MacAndrei, *Baird.*
Philomedes Mariæ, *Baird.*
—— longicornis, *Lilljeborg.*
Polycope orbicularis, *G. O. Sars.*
Cytherella lævis, n. sp.
—— Scotica, n. sp.

Sixty species in all, of which nine are new to science; fifteen (*Paracypris polita, Cythere ventricosa, C. Finmarchica, C. angulata, C. concinna, C. emaciata, Cytheridea inermis, C. dentata, Ilyobates prætexta, Cytherura clathrata, C. acuticostata, C. undata, Bythocythere constricta, Pseudocythere caudata, Polycope orbicularis*) are new to Britain, though they have been described as

inhabitants of other seas, and one (*Cytheropteron tricorne*) is now for the first time noted as occurring in a recent state. It should, however, be mentioned that, of the fifteen species here named as new to our seas, eleven were previously represented in my collection by specimens (unrecorded) from other parts of the British coast.

A species closely allied to *Ilyobates prætexta* (*I. glacialis*, MS.) has been found by Messrs. Crosskey and Robertson pretty abundantly in the fossil state in the oldest deposit of glacial clay which has come under their notice, and it is worthy of remark that the recent species now dredged is much smaller and apparently more poorly developed than the fossil one, though in general character and appearance so much like it as to make me suspect that the one may possibly be the lineal descendant of the other. If this be so, it forms an interesting contrast to *Cytheridea papillosa*, the living specimens of which are mostly much finer than those of the tertiary period. *C. papillosa* is an abundant species in many districts—in Loch Fyne, for instance, it occurs in immense numbers and of fine growth—while *Ilyobates prætexta* appears to be rare, and is probably confined to our northern seas. We may therefore infer that the one species is verging towards extinction, at least in our latitudes, while the other is thriving, and for the present successful in the "struggle for existence." Of the sixty species here catalogued, thirty-two are known to occur in the glacial clays of Scotland; these are marked with an asterisk, and it may be noted that the two species which perhaps occur most abundantly in the older clays, *Cytheridea punctillata* and *Cythere concinna*, do not appear to be of frequent occurrence at the present day, and are confined to northern habitats.

As to the geographical distribution of the various species, it may be remarked that sixteen of the number are essentially northern in their range, so far as our present knowledge extends; these are *Bairdia obtusata*, *B. complanata*, *Cythere concinna*, *C. angulata*, *C. Dunelmensis*, *Cytheridea papillosa*, *C. punctillata*, *C. inermis*, *C. dentata*, *Ilyobates prætexta*, *Bythocythere simplex*, *B. flexuosa*, *Pseudocythere caudata*, *Cytherella lævis*, *C. Scotica*, and *Cypridina MacAndrei*. None of these have been found (except one or two specimens of *Cytheridea punctillata*) in any locality south of the Dogger Bank, and most of them are confined to the shores of Scotland. On the other hand, our list includes one species which attains its highest development in more southern localities, such as the seas around the Channel Islands, the south coast of England, and the south-west of Ireland. This is *Cythere emaciata*, of which only one specimen, and that a poor one, has been detected in the Hebridean gatherings.

It is impossible at present to institute any satisfactory comparison between the recent *Ostracoda* of our seas and those of the Continent, as, except in Scandinavia, scarcely anything has been done amongst this group by continental naturalists. In general terms, however, it may be said that the *Ostracoda* of the Northern British seas exhibit a close approach to those of Norway.

### *Descriptions of new Species.*

PONTOCYPRIS ACUPUNCTATA, n. sp.

Oblong, subgeniform, highest in the middle, height equal to half the length. Anterior extremity rounded, posterior obtusely pointed. Dorsal margin arched, sloping more steeply behind than in front, ventral margin deeply sinuated at the anterior third. Outline, as seen from above, com-

pressed, oval, widest in the middle. Surface minutely punctate. Colour purplish brown. Length $\frac{1}{48}$ in.

*Hab.* The Minch, 45–60 fathoms; and in shell sand from Roundstone.

BAIRDIA COMPLANATA, n. sp.

Subreniform, highest in the middle, greatest height equal to about half the length; anterior extremity evenly rounded, posterior narrowed and somewhat obliquely rounded. Dorsal margin boldly arched, highest in the middle and sloping steeply behind; ventral gently sinuated in front, and slightly convex behind. Outline, as seen from above, compressed, oval; greatest width in the middle, and equal to about one-third of the length. Shell smooth, colour pale ochreous or white. Length $\frac{1}{20}$ in.

*Hab.* The Minch, 45–60 fathoms.

CYTHERE (?) SUBFLAVESCENS, n. sp.

Oval or subtriangular, highest in the middle, greatest height equal to more than half the length, rather tumid. Extremities rounded and nearly equal in width. Superior margin arched, somewhat gibbous in the middle, inferior margin rather convex. Seen from above, oval, widest in the middle, obtusely pointed in front, rounded behind, width equal to nearly half the length. Shell smooth, pale yellow, finely and closely punctate. Length $\frac{1}{50}$ in.

*Hab.* The Minch, 45–60 fathoms.

CYTHERE EMACIATA, n. sp.

Quadrangular, higher in front than behind, length equal to more than twice the height. Anterior margin slightly rounded, often fringed with eight or nine teeth; posterior narrowed, emarginate above, produced and toothed below. Superior and inferior margins nearly straight. Outline, as seen from above, oblong, widest behind, nearly thrice as long as broad. Surface marked with large pits arranged longitudinally; along the middle of the valve a conspicuous elevated rib; a less distinct ridge within the ventral margin, and another smaller oblique rib behind the antero-dorsal angle. Length $\frac{1}{40}$ in.

*Hab.* Hebrides (locality doubtful), and many other places in Great Britain and Ireland.

CYTHERE COMPLEXA, n. sp.

Rhomboidal, excessively tumid below, somewhat higher in front than behind; greatest height equal to two-thirds of the length. Anterior margin rounded; posterior obliquely truncate below, and produced into a short blunt beak above; dorsal margin straight, slightly sloping from the front; ventral margin straight. Seen from above the outline is triangular, with deeply constricted sides, pointed in front, and centrally mucronate behind. Surface rather coarsely reticulated; one tubercle situated near the anterior hinge, and two larger ones with an intermediate connecting ala a little above the ventral margin. Length $\frac{1}{60}$ in.

*Hab.* Uncertain (probably Loch Alsh).

CYTHERURA HUMILIS, n. sp.

Subrhomboidal, nearly equal in height throughout; anterior margin obliquely rounded, sloping steeply above; posterior obliquely truncate. Superior margin very gently arched, sloping steeply behind, inferior straight or

slightly sinuous. Seen from above the outline is oblong, subquadrilateral, obtusely pointed in front, truncate and mucronate behind. Surface irregularly waved; a conspicuous rib parallel to the ventral margin, which gives off in front of the middle another ridge running toward the anterior hinge, which again sends forward from its middle a short longitudinal rib. Length $\frac{1}{15}$ in.

Bythocythere? flexuosa, n. sp.

Elongated, compressed, siliquose; greatest height in the middle, equal to about one-third of the length. Superior margin arched, sloping steeply downwards in front, more gently behind. Extremities obtusely pointed. The ventral margin slightly concave in front, then curving upwards to the posterior extremity. Seen from above compressed oval, widest in the middle, and tapering equally to the extremities, which are somewhat mucronate. Surface smooth, pellucid, with white clouded patches. Hinge-processes feebly developed. Length $\frac{1}{12}$ in.

*Hab.* The Minch, 45–60 fathoms.

Cytherella Scotica, n. sp.

Elliptical, equal in height throughout, height equal to nearly two-thirds of the length; right valve considerably larger than the left; anterior and posterior margins obliquely rounded, superior and inferior margins nearly parallel, gently sinuated in the middle. Outline, as seen from above, subconical; greatest width at the posterior extremity, equal to less than half the length, obtusely rounded, and emarginate in front, rounded behind. Surface marked with very small punctæ. Length $\frac{1}{30}$ in.

*Hab.* The Minch, 45–60 fathoms.

Cytherella lævis, n. sp.

Valves elliptical, broader in front than behind, greatest height equal to two-thirds of the length, broadly rounded in front; rather narrowed, and obliquely rounded behind; dorsal margin gently arched, sloping steeply behind; ventral margin straight, or very slightly incurved. Seen from above the valves are compressed, broadest at the posterior third, and rounded at each extremity; smooth, opaque-white. Length $\frac{1}{37}$ in.

*Hab.* The Minch, 45–60 fathoms.

Only two detached valves of this species were found, but they are sufficiently distinct from *C. Scotica*, the only other British species, to require separate description.

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## *Report on Dredging in the Moray Firth.*

*By the* Rev. Walter Macgregor *and* Robert Dawson.

The Committee appointed by the British Association for the Advancement of Science for dredging the Moray Firth engaged the same vessel as they did last year, and sailed from Macduff on the 13th of July. They continued at sea for fifteen days. During the whole time the weather was most unfavourable, and in consequence the dredgings were in a great measure confined to the western part of the Firth. So stormy was the weather on the 18th, that the vessel was obliged to run into Cromarty Firth.

In the Report laid before the Association at their Meeting of 1865, the number of Mollusca belonging to the district was set down at 259. Since

that Meeting 13 species have been added to the list, distributed as follows:—Of the Cephalopoda, *Eledone octopodia*, *Sepiola Rondeletii*, *Loligo vulgaris*, and *Sepia officinalis*; of the Prosobranchiata, *Mangelia brachystoma*, *M. nebula* and *M. lævigata* (besides *M. pyramidalis* in a fossil state), *Defrancia purpurea*, and *Rissoa costata*; of the Lamellibranchiata, *Arca pectunculoides* and *Leda pygmæa* (two valves of each), both dredged off the Ord of Caithness, and *Scrobicularia nitida*.

It may be worth mentioning, that in Cromarty Bay the dredges were put down in four fathoms of water, and brought up alive *Rissoa costata* in abundance, *Natica Alderi*, *Leda minuta*, *Axinus flexuosus*, *Scrobicularia nitida*, *Corbula gibba*, and *Panopea plicata*.

Of the Crustaceans (Brachyura) found on this and former occasions, may be mentioned *Hyas coarctatus* in spawn (July, October, and November), *Eurynome aspera*, *Portunus puber*, *P. depurator*, *P. marmoreus*, *Ebalia Pennantii*, *E. branchii*, *Atelecyclus heterodon* in great numbers, and *Lithodes Maia*.

Of Anomoura are the following:—*Pagurus lævis*, *Porcellana platychelis* (one specimen) and *P. longicornis* in great abundance, *Galathea strigosa* and *G. dispersa*, *Munida Rondeletii*, *Callianassa subterranea*, *Gebia deltura*, *Calocaris Macandreæ*, *Nephrops norvegicus*, and *Pandalus annulicornis*.

The examination of the Stomapoda has yielded *Vaunthomsonia cristata*, *Eudora*, n. s., and *Bodotria arenosa*.

The Amphipoda normalia, so far as examined, have given *Ampelisca Gaimardii*, *Urothoë marinus*, *Amphithoë rubricata*, and *Corophium Bonelli*. Many of this class remain unexamined.

Of the Isopoda aberrantia may be mentioned *Tanais Dulongii*. The Isopoda are *Cerolana hertipes*, *Æga bicarinata*, and *Rocinela Danmoniensis*.

A Holibut was caught, and off it was taken *Lepeophtheirus hippoglossi*.

The Annelida are as yet unexamined.

Few species of the Echinodermata came up, the only noteworthy one being *Bryssiopsis lyrifer*. One specimen of *Uraster rubens* may be mentioned for its size. It measured 18½ inches across.

The Polyzoa and Hydrozoa yielded nothing worthy of remark, except a fine specimen of *Rhizostoma pulmo*.

The only specimen of the Actinozoa dredged was a very young *Adamsia palliata*. As the Actiniæ, not contained in the former Report, are mentioned in the 'Actinologia Britannica,' it is deemed unnecessary to enumerate them.

The Committee have to return their warmest thanks to Dr. Gray, Mr. Bate, Dr. Bowerbank, and the Rev. A. M. Norman. Without their help, so freely and so kindly given, this Report, as well as the former, would not have been half so complete. The Committee have to express their regret that the weather was so unpropitious, as they have every reason to think that much more would have been accomplished had they reached one or two of the banks on which they were anxious to dredge.

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## *Report of the Committee on the Transmission of Sound-Signals under water.*

At the last Meeting of the Association a Committee, consisting of the Rev. Dr. Robinson, Professor Wheatstone, Dr. Gladstone, and Professor Hennessy, was appointed to Report on the transmission of sound-signals under water.

In the year 1826 M. Colladon made acoustical experiments in the Lake of Geneva, which it is unnecessary to further describe, as a detailed account of

them has been given by Professor Hennessy in a Report, printed in the volume of the Reports of the Association for 1861*.

If these experiments should lead to an available means of communication between two ships in company at sea, or between a ship and the coast during foggy weather, an important purpose would be accomplished.

At first the attention of the Committee was directed to repeating M. Colladon's experiments, substituting for the bell he employed cylindrical bars of steel, from 6 to 8 feet in length, and from 1 inch to 1¾ inch in diameter; these were supported on, or suspended from, their nodal points, and struck with hammers of different weights at one of their ends, so as to excite them longitudinally. These experiments were made in the large water-trough of the Polytechnic Institution, and subsequently in the ornamental waters of the Regent's Park: the available distance in the former case was about seventy yards, in the latter about half a mile. Employing Colladon's ear-trumpet, the sounds were very distinctly heard, and even at the short distance in the Polytechnic, the sounds through the air were separated from those heard through the water by a distinct interval. The character of the sound was, however, very different in the two cases; that transmitted through the water being more abrupt, though in both cases they were mere blows or impulses, as the method of excitation was not intended to produce continuous musical sounds. Though the sounds were not of a character produced by any musical instrument, yet a pitch could be recognized in them in the same manner as a pitch can be perceived in blows made at different parts of a table. By selecting two bars of different lengths, the sounds produced by each might be combined in the different orders of succession, which constitute the telegraphic alphabet. We did not extend these experiments further on account of the expense which would be incurred by the purchase of a sufficient number of bars to enable us to ascertain the best dimensions for the effective production of the required sounds, and also in the expectation that we might, by the operation of some members of the Association, obtain the temporary loan of such materials.

Professor Hennessy, who resides on the sea-side, near Dublin, is willing to undertake such further experiments as would be required for testing the application of sound-signals in extensive spaces out at sea. On this point Dr. Gladstone has already made a few experiments at Eastbourne. He and his children had taken two boats when there was considerable movement on the surface, and the sounds were produced from one boat while they were listened for from the other. Musical sounds appeared to be immediately stopped, while a blow struck end ways on an iron bar could be heard at a great distance.

Sounds produced in the air did not seem to penetrate through the water; but the sound of breaking waves on the shingle of the shore was distinctly heard through the water. This noise heard through the water resembled a series of sharp ticks, and could be easily distinguished at a considerable distance. The detection of this kind of sound is manifestly interesting with reference to the guidance of vessels approaching a coast during the prevalence of a fog. Such noises, though extinguished in their passage through air during a fog, would still be transmitted through water, so as possibly to act at certain parts of the coast as a natural fog-signal.

The attention of the Committee has been specially directed to the production of musical sounds under water. The instruments which appeared to be most available for this purpose were Cagniard de la Tour's Syren, and pipes or whistles, in which the vibrations were caused by currents of water in masses

* Thirty-first Report, p. 173.

of the same liquid. When limited volumes of water were employed, powerful sounds were obtained in both cases; but in large reservoirs we met with an unexpected difficulty, for we found that musical sounds, which could be heard through considerable distances in air, became totally extinguished at very short distances from the point of origin in water. Even when sounds were produced with considerable intensity in a confined vessel, as a pail or tub, when the vessel was plunged in a large reservoir the sound communicated to the air became remarkably deadened, and the intensity was more diminished as the instrument was placed at a greater distance beneath the surface of the water. The rapid extinction of musical sounds in water renders it almost hopeless to employ them for communicating signals in that medium. We must therefore, if this investigation is to be continued, revert to experiments similar to those of M. Colladon, and confine ourselves to the transmission of shocks or impulses communicated to bars or pieces of metal of various forms and dimensions.

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*Report of the Lunar Committee for Mapping the Surface of the Moon.* *By* W. R. Birt, *at the request of the Committee, consisting of* James Glaisher, *F.R.S.*, Lord Rosse, *F.R.S.*, Sir John Herschel, *Bart., F.R.S.*, Professor Phillips, *F.R.S.*, Warren De la Rue, *F.R.S.*, Rev. W. R. Dawes, *F.R.S.*, Rev. T. W. Webb, *F.R.A.S.*, J. N. Lockyer, *F.R.A.S.*, H. S. Ellis, *F.R.A.S.*, Herr Schmidt, *and* W. R. Birt, *F.R.A.S.*

In the Report which I had the honour to present to the Members of the British Association for the Advancement of Science at Birmingham, the steps taken by the Committee appointed at Bath for ensuring as full and accurate a Register of Lunar Objects as could be obtained, were described in detail with the Forms issued by the Committee for obtaining this object, to which were added a few notices of the more remarkable features of the Lunar Surface which had presented themselves in the course of observation.

It was in the first instance proposed to construct an outline Map of the Moon's Surface four times the area of that of Beer and Mädler, or 75 inches in diameter; every object entered in the Register to be inserted on the Map: the outline of a Map of this size was exhibited to the Section.

In the Resolution reappointing the Committee, the object expressly mentioned, is that "of making further progress in mapping the surface of the Moon;" and while the Committee has not lost sight of the objects contemplated in its original appointment, it has, in consequence of some remarks of the President of the Association, Professor Phillips, when the Report was read, mainly directed its efforts to the construction of an accurate outline Map of 100 inches in diameter.

In noticing the progress made in this department of its labours, it may be well to glance at the materials at present available for the purpose. These are, well-determined positions of the First Order, and existing Photographs.

In Appendix I. will be found the rectangular coordinates of all the positions of the first order determined up to the time of Beer and Mädler. I am not aware that any have been determined since, unless Herr Schmidt, of Athens, may have added to the number, but his measures are as yet unpublished.

Of existing photographs, I am aware of only one that can be employed in connexion with positions of the first order for obtaining an approximation to the true places of *unmeasured* points; but this, which was taken by Warren De La Rue, Esq., on October 4, 1865, at $9^h\ 0^m\ 4^s$, G. M. T., represents the disk at an epoch so near that of mean libration, which occurs only once in three years, that the abscissæ X may be measured on it without appreciable error, and the ordinates Y require but a small correction. I now proceed to notice the work done under these heads.

My first step was to project orthographically on one sheet of paper a quadrant of the moon's disk of 50 inches radius. The quadrant chosen as the most convenient was the fourth. After laying down the meridians and parallels, I inserted in this quadrant all the points of the first order, amounting only to twenty-three (see Appendix I.). It is greatly to be regretted that these points are so *few*, and that the triangles of which they form the points are so *large*, as in employing photographs taken at any other epoch than that of mean libration, or, indeed, by using any method, so far as I am aware, *except determinations of the first order*, libration enters so extensively, that even at short distances from these points the results of measures become very uncertain; and as the formulæ for computing the existing libration at any given epoch are only available for determining the selenographical longitude and latitude of the centre of the apparent disk at that epoch, and do not assist in the determination of the position of any other point except by the aid of direct measures and the computation of certain angles, it is the more important to augment the number of positions of the first order. With this view, I have prepared from Lohrmann's work, 'Topographie der Sichtbaren Mondoberfläche,' compared with Beer and Mädler's 'Der Mond,' a modification of the forms adopted by those selenographers for this purpose according to the method of Encke, which necessarily includes the computation of the libration. (See Appendix II.)

The twenty-three points of the first order in Quadrant IV. were carefully laid down by direct measurement from the equator and first meridian, and checked in every case by measuring from point to point the sides of the triangles formed by them, and given by Beer and Mädler in 'Der Mond,' pp. 80–82. Taking the moon's semidiameter equal unity, the greatest error (a solitary instance) amounted to ·0008, which is much less than errors arising from contraction &c. of the paper employed. In addition to points of the first order, several of the second order have been inserted.

The coincidence of the equator of the photograph of October 4, 1865, enlarged to 10 inches in diameter, with that of the moon was next ascertained. At mean libration the moon's equator is projected on the disk as a straight line, and if the photograph be taken at the exact instant of mean libration, the moon's equator will coincide with a straight line across the disk equally distant from each pole. The appearance of the moon when full differs, as is well known, from that which is presented at the various phases; many prominent objects quite disappear, and it is not so easy to pick out those that can be seen as when they are near the terminator. I was able, however, to ascertain, with some degree of precision, the following points:—South of the Equator—Messier, Theophilus, Dollond, Albategnius, Herschel, and Gassendi; North of the Equator—Picard, Dionysius, Linné Aristillus, Pico, and Kepler. Appendix IV. contains the measures of these points from the apparent equator on the photograph, and the comparison of them with the abscissæ of the same points given by Beer and Mädler. The mean difference for those south of the equator is ·0019, and for those north of the equator

·0052, moon's semidiameter = 1·0. It is consequently assumed that measures for latitude south of the equator will not involve any great error in transferring them to the larger scale of 100 inches. The libration in latitude $=-0^\circ\ 20' \pm$; in longitude $-\ 0^\circ\ 40' \pm$.

The measures of the above-named points, from the apparent central meridian for longitude, were, as might be expected from the greater amount of libration in longitude, not so accordant with the ordinates as those for latitude were with the abscissæ; the mean of the most accordant differences west of the meridian amounts to as much as ·0195, while east = ·007. A correction of ·020 has consequently been applied to all measures west of the meridian. Under these circumstances, it is considered that as close an approximation as a combination of direct measurement with measures on photographs *taken at or near the epoch of mean libration* will afford, has been obtained for the basis of the Map. Still, for obvious reasons, it would be well to augment positions of the first order, especially as outlines laid down from a photograph taken at full moon differ materially from those furnished by a photograph taken at an earlier or later phase.

Among the forms issued by the Committee last year was one (Form No. 2) for aiding in the formation of a catalogue of lunar objects by symbolizing them (see Report, 1865, p. 288), by means of which each area of 5° of latitude and 5° of longitude is distinguished by a distinct symbol, IV $A^{\alpha}$, IV $A^{\beta}$, &c., for example. Every object discernible on the photograph of October 4, 1865, between 0° and 15° of longitude and 0° and 10° of latitude, has been carefully measured, and inserted on the projection of Quadrant IV. above-mentioned, the areas included being IV $A^{\alpha}$, IV $A^{\beta}$, IV $A^{\gamma}$, IV $A^{\zeta}$, IV $A^{\eta}$, and IV $A^{\theta}$. The angular points bounding the portion of the surface thus measured are as follows:—The centre of the moon's visible disk in mean libration, and the region between Ptolemæus and Albategnius on the east, and Dollond and Theon Senior on the west. This region forms part of the mountainous district between the *Sinus Medii* and *Mare Tranquillitatis*, and is characterized by great diversity and irregularity of surface. As the direction in which the light is received from the moon when full is nearly the same—but reversed—as that in which it falls upon the surface from the sun, it is clear we have on the photograph of the full moon the "ground markings" on the visible disk destitute of all hypsometrical affections, and the light and shade indicate the reflective power of the surface only. There are a variety of degrees of reflective power; but from an attentive consideration of the photograph, they may generally be regarded as *five*, from the bright white surface surrounding many craters to the dark surfaces of the *Maria*. A tracing of the markings thus laid down has been executed, in which a conventional mode has been introduced for distinguishing the variety of tints. This tracing is very useful for comparing the features of the full moon with those observed at earlier and later phases, and some interesting results have been obtained, to which allusion will be made presently.

If the features of the full moon only were laid down on a map, the student would be utterly unable to recognize any of the minute details which are seen near the terminator. In the absence of a photograph taken sufficiently near the epoch of mean libration for the coordinates of each object as seen near the terminator to be measured, that it may at once be transferred to its proper place on the Map (opportunities for obtaining such a photograph will not occur until 1868), the mode that presents itself for dealing with the more minute details is to measure on another photograph such details from the *nearest point of the first order*, having identified as nearly as possible the

corresponding prominent features in the two photographs. As before remarked, the photograph of October 4, 1865, is that of full moon; the one employed for the smaller and more striking detail is that taken by Warren De La Rue, Esq., on February 22, 1858, enlarged on glass to 8·75 inches in diameter. On neither of the six areas above mentioned does a point of the first order occur, and the nearest to areas IV $A^{\alpha}$, IV $A^{\zeta}$ is the central mountain of Albategnius in IV $A^{\lambda}$. From the very nature of the apparent changes effected in the visible disk by libration, it is clear that such measures as those just alluded to cannot possess much claim to accuracy when referred to the mean projection, *except when made in the immediate neighbourhood of a point of the first order*, or near a point that has been well identified; all other positions can only be considered as approximate; indeed, when the lines measured approach the tenth part of the moon's semidiameter in length they are quite useless; still, with a proper amount of care the approximation capable of being attained may be sufficiently close for all the purposes of a map, especially if all well-determined positions be distinctly indicated. The reader may easily convince himself of the difficulty of combining portions of photographs taken at differing intervals from the epoch of mean libration by simply making enlarged tracings of such portions and superposing the one on the other; he will soon see they will not fit; added to this is the effect produced by variation of distance; two photographs taken at mean libration will not quite agree, the features of that taken at perigee will manifestly be larger than if it were taken at apogee.

Notwithstanding these difficulties, numerous objects have been inserted on Areas IV $A^{\alpha}$, IV $A^{\beta}$, IV $A^{\zeta}$, and IV $A^{\eta}$ from the photograph of February 22, 1858, and other sources, and a drawing made of the area IV $A^{\zeta}$. This has been enlarged to a scale of 400 inches = moon's diameter*. Each object, as it is inserted in the map and drawing, is entered in Form No. 3. (See Report, 1865, p. 296.) Appendix III. contains a catalogue of these objects. The numbers in each of the above-named areas are as follows:—IV $A^{\alpha}$, 88, IV $A^{\beta}$, 21, IV $A^{\zeta}$, 114, IV $A^{\eta}$, 25.

There are a few points of interest which attach to the features thus inserted. It is well known that Tycho is the centre of the most magnificent system of rays or lucid bands on the moon's surface, and that this system is seen to the greatest advantage at the time of full moon; accordingly, the photograph of October 4, 1865, furnishes the best means for depicting under that aspect, the rays emanating from Tycho. Three of these rays cross the areas above-mentioned; the two eastern rays cross the areas IV $A^{\alpha}$, IV $A^{\zeta}$, and the west ray crosses the areas IV $A^{\beta}$, IV $A^{\eta}$. These rays will be referred to in Appendix III., which contains an abbreviated catalogue of the objects already mapped and inserted in the drawings; nevertheless it may be proper to mention here that all three are coincident with ranges of high land, as seen in the photograph of February 22, 1858, which in some places are much broken, and in others rise into rocky eminences. The middle of these rays passes along the east border of Albategnius, and the western along the west border. The west border of Ptolemæus forms part of the eastern ray.

Another feature bearing remotely on the above-named areas is the existence of two "ray-centres" in the neighbourhood of Furnerius. These ray-centres are depicted by Hevelius in his Selenographia, figs. O and P, similar as Beer and Mädler remark to two pairs of crab-claws, the rays going north-

* It was exhibited at the Meeting.

ward. It appears from 'Der Mond,' p. 375, that Beer and Mädler not only saw one of the northern branches extending from Furnerius A about fifty-five English miles, but also traced a southern and *brighter* branch from this crater extending as far as ninety English miles. They appear to be silent as to any radiating streaks. Beer and Mädler also speak of one near Stevinus. I have not yet been able to identify Beer and Mädler's positions. These "ray-centres" are quite perceptible on the photograph, and the rays can be well traced as far as the neighbourhood of Godin and Agrippa. The rays from the easternmost centre bend round, and form branches of parabolic curves. In areas III $A^{\zeta}$, IV $A^{\zeta}$, and IV $A^{\eta}$, there is a considerable parallelism between several of the mountain-ranges and valleys, and these are seen on the photographs, taken when Copernicus is near the terminator, gradually to fall into the curves formed by the rays from the east centre. The valleys and mountain-ranges are particularly specified in Appendix III.

The occurrence of "light-centres," hitherto, I believe, unnoticed*, is another feature of much interest. There are in the mountainous district before mentioned, between the *Sinus Medii* and *Mare Tranquillitatis*, four such centres. They appear to be subordinate to ray-centres, are generally in immediate connexion with craters, the interiors of which are very bright, and the light spreads more or less regularly on all sides of them, as if the surface around them consisted of strongly reflective materials. The north border of the crater and light-centre IV $A^{\eta\,2}$, which is very deep, is *cracked*, and the crack appears to penetrate the depth of the crater. This crack forms the south part of the rill No. 362 of Schmidt's Catalogue, and is connected with a "fault" which extends as far as and dislocates the west border of Rhæticus in the neighbourhood of the equator. If the crack, rill, and fault originated at an epoch when IV $A^{\eta\,2}$ was in a state of activity, the convulsion of the interior must have been considerable, IV $A^{\eta\,2}$ being about 7° south of the equator, although nothing in comparison with that which produced the bands issuing from Tycho and the two ray-centres in the south-west.

* During the passage of these sheets through the press, the Rev. T. W. Webb called my attention to Beer and Mädler's remarks on the crater "Euclides," as showing that it belongs to the class of "light-centres." Mr. Webb has kindly favoured me with a translation, and Beer and Mädler's observations are so much to the point that I gladly insert them. For the original consult 'Der Mond,' p. 313.

"Euclides especially distinguishes itself among the *light-surrounded* (which are by no means to be confounded with the radiating) craters. It is encompassed by a very bright luminous area, rather triangular than circular, brightest at its foot, but losing itself indefinitely on every side. It may be perceived as far as K and ξ, and consequently about 6 miles (27·6 miles English) away to the north. The whole lucid spot is quite flat and lies in the level of the *Mare*, with the exception of some very inconspicuous hills that are of no importance in comparison with the wall of Euclides.

"This altogether peculiar *whitish* nimbus shows itself only near a few craters of the moon's surface, of which not one has more than 1½ mile (about 7 miles English) in diameter, and they almost all lie between 7° 30′ and 46° of longitude, and between the equator and 15° of latitude. The radiating ring mountains are collectively much larger, do not show their greatest brightness immediately at the foot, and extend this brightness in long streaks. Craters with a brighter neighbourhood, which generally arises from surrounding terraces, show themselves in abundance, but we may soon convince ourselves by mere inspection that this has nothing in common with the here mentioned appearance. The craters belonging to this class are collectively very deep, strictly circular, never less than 7° bright, little differing in respective magnitude, and extremely obvious under every illumination. The luminosity near Mösting c is quite of another nature, and that near Lichtenberg does not show itself on every side, is fainter, and light-red rather than whitish."

The four areas IV $A^{\alpha}$, IV $A\beta$, IV $A\zeta$, and IV $A^{\eta}$ are characterized by several faults; the particulars of those in IV $A^{\alpha}$ and IV $A\zeta$ will be found in Appendix III.

In the Report presented at Birmingham, allusion was made to the measurement of the diameters of craters for the determination of magnitude. It is worthy of remark that measures have been taken of some of the larger craters inserted in areas IV $A\beta$ and IV $A^{\eta}$, and upon comparison these measures have been found to agree nearly with those taken from the photograph.

During the past year Herr Schmidt, of Athens, has issued a catalogue of 425 rills; 278 of these have been discovered by himself. They consist of rills, crater-rills, crater-rows, and valleys with some faults. In the catalogue of objects on area IV $A\zeta$, which forms part of Appendix III., are eight not to be found in his printed catalogue. Four of these have been discovered since July 20, 1866. The great fault crossing the area from Tycho is not included.

The number of series of observations of the moon's surface as described in the last Report (Report, 1865, p. 303), now amount to 490. The progress of the actual work as regards the registration of the objects observed, and others of a conspicuous character on the moon's surface during the past year, is shown in the following digest.

At the Bath Meeting 386 objects were symbolized and registered; at the Birmingham Meeting 785; and at the Nottingham Meeting 1321; of these 536 were symbolized and registered in the fifty weeks between the Meetings of the Association at Birmingham and Nottingham.

The 1321 objects are disposed over the moon's surface as follows:—

| | | | | | |
|---|---|---|---|---|---|
| 396 | on | 70 | areas | in Quadrant | I. |
| 346 | „ | 86 | „ | „ „ | II. |
| 163 | „ | 53 | „ | „ „ | III. |
| 416 | „ | 62 | „ | „ „ | IV. |
| Total 1321 | | 271 | areas* | on the moon's surface. | |

Previous to the Meeting at Birmingham, the regions and groups that had been the subjects of special observation were:—On Quadrant I. the rill system of Triesnecker; the great rill of Ariadæus; the Plain of Dionysius; the walled formation Posidonius, and the Mare Crisium, especially the craters on its surface. (See Report, 1865, pp. 292, 293.) On Quadrant II. the Teneriffe Mountains, Plato, and its neighbourhood, and the valley J. J. Cassini. On Quadrant III. the walled plain Gassendi, and the tableland "Terra Photographica" (De La Rue).

The extension of the Register by the addition of 536 objects during the past year, has reference, first, to the symbolization of points of the first order. Beer and Mädler have expressed these points in their list—which I have of course followed—too vaguely, and it requires some searching in the topographical part of 'Der Mond' to find the exact object intended. By appending the symbol, as I have done in Appendix I., when the Register is sufficiently advanced for publication in a consecutive from, the identification of each point will be easy. Second, the mapping out of the areas IV$A^{\alpha}$, IV$A\beta$, IV$A^{\gamma}$, IV$A\xi$, IV$A^{\eta}$, and IV$A^{\theta}$, has necessarily involved the symbolization of the objects on this part of the moon, so that to the above-named regions that of Hipparchus and its neighbourhood may now be added.

* The reader will find a description and symbolization of these areas in the Report of the Lunar Committee presented at Birmingham. (Report, 1865, p. 287 *et seq.*)

## Appendix I.

*Points of the First Order.*

| Zone. | Symbol. | Name. | Lat. N. | Long. W. | $X^a$. | $Y^a$. |
|---|---|---|---|---|---|---|
| **Quadrant I.** | | | | | | |
| | | | ° ′ ″ | ° ′ ″ | | |
| I. | $I\,D^{\alpha 2}$ | Schubert A | 2 27 42 | 77 15 51 | ·04295 | ·97449 |
| I. | $I\,B^{\alpha 1}$ | Maskelyne | 2 31 38 | 29 34 58 | ·04409 | ·49332 |
| I. | $I\,A^{\delta 6}$ | Dionysius | 2 50 55 | 17 8 40 | ·04970 | ·29442 |
| I. | $I\,A^{\gamma 8}$ | Agrippa | 4 4 16 | 10 22 13 | ·07099 | ·17955 |
| III. | $I\,B^{\alpha 2}$ | Taruntius | 5 40 10 | 45 58 24 | ·09879 | ·71550 |
| V. | $I\,C^{\alpha 2}$ | Hansen A | 13 17 19 | 74 0 8 | ·22985 | ·93563 |
| V. | $I\,A^{\kappa 2}$ | Manilius | 14 26 54 | 8 46 56 | ·24949 | ·14824 |
| V. | $I\,C^{\lambda 1}$ | Picard | 14 27 44 | 53 52 8 | ·24974 | ·78208 |
| VII. | $I\,A^{\nu 2}$ | Plinius | 15 17 20 | 23 23 28 | ·26369 | ·38287 |
| VII. | $I\,B^{\nu 2}$ | Proclus | 16 9 8 | 46 31 34 | ·27819 | ·69704 |
| VII. | $I\,B^{\rho 2}$ | Vitruvius | 17 36 10 | 31 2 5 | ·30229 | ·49165 |
| IX. | $I\,A^{\phi 1}$ | Conon | 21 31 27 | 1 57 18 | ·36689 | ·03173 |
| XI. | $I\,F^{\gamma 2}$ | Römer | 25 18 51 | 36 19 6 | ·42758 | ·53540 |
| XI. | $I\,F^{\alpha 2}$ | Le Monnier A | 25 59 30 | 29 3 50 | ·43824 | ·43665 |
| XI. | $I\,E^{\gamma 1}$ | Linné | 27 47 13 | 11 32 28 | ·46618 | ·17697 |
| XI. | $I\,G^{\alpha 3}$ | Cleomedes A | 28 23 58 | 54 17 25 | ·47562 | ·71427 |
| XIII. | $I\,F^{\zeta 2}$ | Posidonius A | 31 35 39 | 29 7 24 | ·52389 | ·41455 |
| XIII. | $I\,E^{\zeta 4}$ | Aristillus | 33 45 27 | 1 0 42 | ·55567 | ·01468 |
| XVII. | $I\,E^{\alpha 2}$ | Cassini A | 40 22 44 | 4 8 55 | ·64784 | ·05512 |
| XVII. | $I\,F^{\nu 5}$ | Cepheus A | 40 59 20 | 45 39 42 | ·65592 | ·53986 |
| XVII. | $I\,G^{\sigma 3}$ | Struve B | 43 20 14 | 64 47 4 | ·68629 | ·65802 |
| XVII. | $I\,F^{\pi 5}$ | Burg | 44 57 9 | 27 31 57 | ·7c651 | ·32714 |
| XIX. | $I\,F^{\downarrow 3}$ | Hercules | 46 23 22 | 38 23 26 | ·72405 | ·42834 |
| XXIII. | $I\,L^{\zeta 3}$ | Endymion G | 56 28 30 | 54 18 26 | ·83364 | ·44856 |
| XXIII. | $I\,I^{\alpha 2}$ | Aristotelis C | 57 26 3 | 23 33 42 | ·84277 | ·21516 |
| XXIII. | $I\,I^{\zeta 2}$ | Archytas | 58 24 1 | 4 13 3 | ·85173 | ·03854 |
| XXV. | $I\,K^{\alpha 1}$ | Thales | 61 58 24 | 49 12 23 | ·88273 | ·35573 |
| XXV. | $I\,K^{\mu}$ | Democritus | 62 8 21 | 33 30 21 | ·88406 | ·25797 |
| **Quadrant II.** | | | Lat. N. | Long. E. | | |
| I. | $II\,A^{\delta 2}$ | Gambart A | 0 50 30 | 18 45 12 | ·01469 | ·32138 |
| III. | $II\,C^{\zeta 2}$ | Reiner | 6 30 37 | 54 43 41 | ·11335 | ·81115 |
| III. | $II\,A^{\zeta 1}$ | Bode | 6 37 54 | 2 30 48 | ·11549 | ·04356 |
| III. | $II\,B^{\theta 2}$ | Kepler | 7 46 13 | 37 42 18 | ·13520 | ·60597 |
| III. | $II\,D^{\zeta 2}$ | Olbers | 7 55 16 | 77 32 31 | ·13781 | ·96729 |
| III. | $II\,A^{\iota 2}$ | Copernicus | 9 20 57 | 19 55 48 | ·16245 | ·33634 |
| V. | $II\,A^{\nu 2}$ | Eratosthenes | 14 25 46 | 11 32 11 | ·24919 | ·19368 |
| VII. | $II\,B^{\pi 2}$ | T. Mayer | 15 32 30 | 28 49 41 | ·26794 | ·46455 |
| IX. | $II\,A^{2}$ | Pytheas | 20 14 3 | 20 34 13 | ·34586 | ·32968 |
| IX. | $II\,C^{\omega 2}$ | Seleucus | 20 54 21 | 65 48 19 | ·35683 | ·85211 |
| IX. | $II\,B^{\Phi 2}$ | Euler | 22 57 51 | 28 56 59 | ·39016 | ·44567 |
| IX. | $II\,B^{2}$ | Aristarchus | 23 17 17 | 47 12 9 | ·39536 | ·67397 |
| XI. | $II\,E^{\gamma 2}$ | Timocharis | 26 42 44 | 12 59 44 | ·44951 | ·20086 |
| XI. | $II\,F^{\alpha 1}$ | La Hire | 27 18 25 | 25 9 40 | ·45875 | ·37777 |
| XI. | $II\,F^{\beta 2}$ | Delisle | 29 59 20 | 34 47 57 | ·49984 | ·49430 |
| XIII. | $II\,F^{\pi 1}$ | Wollaston | 30 17 15 | 46 54 14 | ·50434 | ·63052 |
| XIII. | $II\,G^{\iota 1}$ | Lichtenberg | 31 25 20 | 67 5 3 | ·52134 | ·78601 |
| XIII. | $II\,E^{\pi 1}$ | Carlini | 33 22 45 | 24 0 46 | ·55017 | ·33982 |
| XVII. | $II\,F^{\rho 1}$ | Heraclides | 41 7 46 | 34 1 25 | ·65776 | ·42144 |
| XVII. | $II\,G^{\upsilon 1}$ | Harding | 43 8 41 | 70 52 10 | ·68385 | ·68933 |
| XVII. | $II\,F^{\pi 2}$ | Laplace A | 43 16 21 | 26 33 33 | ·68545 | ·32558 |
| XIX. | $II\,E^{\chi 16}$ | Pico | 45 28 7 | 9 12 31 | ·71287 | ·11223 |
| XXI. | $II\,K^{\delta 2}$ | Harpalus | 52 28 41 | 43 36 20 | ·79310 | ·42005 |
| XXV. | $II\,L^{\nu 2}$ | Pythagoras A | 63 3 44 | 61 36 45 | ·89150 | ·39854 |
| XXVII. | $II\,I^{\sigma 1}$ | Epigenes II | 67 53 30 | 10 31 0 | ·92647 | ·06869 |

APPENDIX I. (*Table continued*).

| Zone. | Symbol. | Name. | Lat. S. / Lat. N. | Long E. / Long. W. | X*. | Y*. |
|---|---|---|---|---|---|---|
| | | **Quadrant III.** | | | | |
| II. | III $B^{\alpha 2}$ | Landsberg | 0 29 51 | 26 33 49 | ·00868 | .44716 |
| II. | III $A^{\beta 2}$ | Lalande | 4 20 3 | 8 44 23 | ·07557 | ·15151 |
| II. | III $B^{\delta 1}$ | Flamsteed | 4 30 48 | 44 12 8 | ·07864 | ·69502 |
| II. | III $C^{\epsilon 2}$ | Grimaldi A | 4 54 27 | 70 53 28 | ·08555 | ·94141 |
| IV. | III $A\zeta^{3}$ | Herschel | 5 37 6 | 2 9 7 | ·09789 | ·03737 |
| IV. | III $B\zeta^{1}$ | Euclides | 7 10 21 | 29 15 47 | ·12485 | ·48500 |
| IV. | III $A^{\iota 2}$ | Parry A | 9 19 44 | 15 39 40 | ·16210 | ·26638 |
| VI. | III $A^{\lambda 3}$ | Alphonsus A | 12 59 21 | 3 14 28 | ·22477 | ·05509 |
| VI. | III $B^{\circ 1}$ | Billy | 13 59 45 | 49 57 40 | ·24185 | ·74288 |
| VIII. | III $C^{\tau 1}$ | Crüger | 16 45 37 | 66 40 15 | ·28836 | ·87925 |
| VIII. | III $B^{\sigma 4}$ | Gassendi | 16 55 40 | 39 31 37 | ·29117 | ·60885 |
| X. | III $A^{3}$ | Bullialdus | 20 25 56 | 22 6 11 | ·34910 | ·35260 |
| X. | III $C^{2}$ | Eichstädt B | 20 31 15 | 70 27 9 | ·35054 | ·88256 |
| X. | III $AX^{2}$ | Thebit A | 21 17 34 | 5 47 8 | ·36312 | ·09392 |
| X. | III $D^{\Phi 1}$ | Eichstadt | 21 39 1 | 77 17 7 | ·36894 | ·90665 |
| X. | III $C^{\Psi 1}$ | Byrgius | 24 22 43 | 63 30 5 | ·41277 | ·81515 |
| XII. | III $E^{\zeta 2}$ | Hesiodus B | 26 50 26 | 16 59 35 | ·45150 | ·26077 |
| XII. | III $F^{\alpha 2}$ | Campanus | 27 36 50 | 27 27 1 | ·46351 | ·40847 |
| XIV. | III $F^{\theta 2}$ | Vitello | 30 0 26 | 37 8 26 | ·50010 | ·52264 |
| XIV. | III $E^{\eta 2}$ | Hell | 31 58 59 | 8 19 54 | ·52967 | ·12291 |
| XIV. | III $F^{\eta 2}$ | Ramsden | 32 25 48 | 31 41 55 | ·53627 | ·44351 |
| XIV. | III $G^{\eta 1}$ | Fourier B | 32 40 50 | 56 49 40 | ·53996 | ·70451 |
| XVIII. | III $F^{\nu 1}$ | Drebbel | 40 47 21 | 48 12 39 | ·65328 | ·56449 |
| XVIII. | III $E^{\sigma 2}$ | Tycho | 42 52 19 | 11 52 25 | ·68036 | ·15079 |
| XVIII. | III $F^{\pi 1}$ | Hainzel A | 42 59 26 | 29 24 45 | ·68187 | ·35839 |
| XX. | III $EX^{2}$ | Maginus A | 49 57 17 | 7 5 50 | ·76553 | ·07949 |
| XXII. | III $L^{\beta 1}$ | Phocylides E | 54 34 48 | 55 34 35 | ·81493 | ·47807 |
| XXIV. | III $I^{\Theta 2}$ | Clavius C | 57 16 47 | 14 40 26 | ·84132 | ·13693 |
| XXIV. | III $K\zeta^{2}$ | Scheiner A | 59 58 26 | 26 36 13 | ·86580 | ·22407 |
| XXVIII. | III $I^{\rho 2}$ | Moretus | 69 45 25 | 7 8 38 | ·93823 | ·04303 |
| | | **Quadrant IV.** | | | | |
| II. | IV $B^{\beta 1}$ | Censorinus | 0 26 35 | 32 21 31 | ·00773 | ·53520 |
| II. | IV $A^{\delta 2}$ | Delambre | 1 47 17 | 17 15 9 | ·03120 | ·29644 |
| II. | IV $B^{\epsilon 1}$ | Messier | 1 58 55 | 47 9 12 | ·03458 | ·73274 |
| IV. | IV $B^{\eta 2}$ | Capella | 7 32 41 | 34 48 14 | ·13130 | ·56582 |
| IV. | IV $C^{\Theta 1}$ | Langrenus | 8 22 29 | 60 34 9 | ·14561 | ·86165 |
| IV. | IV $C^{\alpha 1}$ | Lapeyrouse A | 9 23 20 | 73 52 41 | ·16313 | ·94779 |
| IV. | IV $B^{\iota 1}$ | Goclenius | 9 58 46 | 44 27 2 | ·17329 | ·68970 |
| VI. | IV $A^{\nu 1}$ | Dollond | 10 14 59 | 14 11 53 | ·17794 | ·24136 |
| VI. | IV $B^{\lambda 1}$ | Theophilus | 11 21 3 | 26 18 16 | ·19682 | ·43447 |
| VI. | IV $A^{\lambda 2}$ | Albategnius | 11 21 20 | 3 58 13 | ·19689 | ·06788 |
| VI. | IV $A^{\circ 1}$ | Cyrillus A | 13 30 3 | 22 41 20 | ·23346 | ·37657 |
| X. | IV $C^{\Phi 1}$ | Biot | 22 20 16 | 50 4 24 | ·38007 | ·70932 |
| X. | IV $A^{\omega 2}$ | Sacrobosco A | 23 42 5 | 15 40 55 | ·40197 | ·24749 |
| X. | IV $CX^{2}$ | Petavius A | 24 38 51 | 59 15 48 | ·41733 | ·78111 |
| XII. | IV $E^{\alpha 1}$ | Werner | 27 45 42 | 2 58 10 | ·46580 | ·04584 |
| XII. | IV $F^{\beta 2}$ | Piccolomini | 29 10 50 | 31 35 22 | ·48756 | ·45519 |
| XIV. | IV $E^{\kappa 2}$ | Lindenau | 31 52 6 | 24 29 31 | ·52797 | ·35206 |
| XIV. | IV $G^{\eta 2}$ | Furnerius A | 33 6 4 | 57 51 52 | ·54612 | ·70937 |
| XVIII. | IV $F^{\tau 2}$ | Fabricius | 42 8 0 | 40 46 0 | ·67086 | ·48424 |
| XVIII. | IV $E^{\sigma 2}$ | Maurolycus A | 43 23 20 | 13 40 47 | ·68694 | ·17186 |
| XVIII. | IV $G^{\tau 1}$ | Vega A | 44 56 54 | 68 44 0 | ·70646 | ·65955 |
| XX. | IV $F^{\Phi 2}$ | Pitiscus A | 49 58 43 | 29 32 49 | ·76581 | ·31712 |
| XXVI. | IV $K^{\lambda 1}$ | Mutus | 63 6 5 | 29 21 50 | ·89181 | ·22183 |

* In the last Report (Report, 1865, p. 295) will be found an explanation of the coordinates X and Y, with the formulæ for computing them when the position of the object on the moon's surface has been determined.

*Addenda to Appendix* I.

Beer and Mädler, with the view of determining the position of the north pole of the moon, ascertained by measures of the First Order, direct and differential, the latitudes and longitudes of the following points (all mountains):—Euctemon e and $\delta$, Gioja $\gamma$, three with high northern latitudes and west longitudes considerably exceeding 90°, Anaxagoras $\iota$ within 5° of the pole and 108° east longitude, and Gioja $\alpha$ within 2° of the pole and 7° east longitude; the last comes within the orthographical projection mean libration, the others are not visible in mean libration. The drawing of these and neighbouring points (without the parallel and declination-circles) forms Table I. of Beer and Mädler's 'Beiträge zur physischen Kenntniss der himmlischen Körper im Sonnensysteme.' The observations and results are recorded on pp. 66 and 67. The best time for comparing the drawing with the moon is when she has high south latitude.

| | Lat. | Long. |
|---|---|---|
| | ° ′ ″ | ° ′ ″ |
| Euctemon e..... | 78 1 46 N. | 126 37 35 W. |
| Euctemon $\delta$..... | 83 16 27 N. | 118 0 40 W. |
| Gioja $\gamma$..... | 86 44 33 N. | 174 46 33 W. |
| Anaxagoras $\iota$ ..... | 85 24 0 N. | 108 14 35 E. |
| Gioja $\alpha$..... | 88 4 41 N. | 7 2 9 E. |

APPENDIX II.—DETERMINATION OF POINTS OF THE FIRST ORDER.

*Explanation of Terms used in this Appendix.*

LIBRATION IN LATITUDE arises principally from the northern and southern parts of the lunar globe coming alternately into view in consequence of the inclination of the plane of the moon's orbit to that of the ecliptic.

LIBRATION IN LONGITUDE arises from the same hemisphere of the moon being constantly directed, *not towards the earth*, but towards the other focus of the elliptic orbit of the moon, in consequence of which, while the moon describes the perigean portion of her orbit, the first meridian, from which all selenographical longitudes are reckoned, is gradually transferred from west to east. The same meridian is transferred from east to west during the period that the moon describes the apogean part of her orbit. The same hemisphere being directed always towards the other focus of the elliptic orbit, is the result of the uniformity of the rotation of the moon on her axis.

GEOCENTRIC LATITUDE AND LONGITUDE of the moon's centre is the latitude and longitude of the moon's centre as seen from the earth's centre reckoned from and on the ecliptic.

SELENOCENTRIC LATITUDES AND LONGITUDES are latitudes and longitudes of points on the moon's surface as seen from the centre of the moon. Latitudes are reckoned *from* the moon's equator, and longitudes are reckoned *on* the moon's equator from the point at which the moon's equator intersects the ecliptic. This point, which is the ascending node of the moon's equator, is rigorously identical with the descending node of the moon's orbit.

SELENOGRAPHICAL LATITUDES AND LONGITUDES are the latitudes and longitudes of points of the moon's surface reckoned as on the earth's surface from the equator of the moon and the first meridian. See fig. 6, p. 228.

*General Principles.*

1. The great importance of augmenting the number of points of the first order—for the purpose of mapping the surface of the moon on a large scale, and more especially for drawing up monograms of special portions on a still

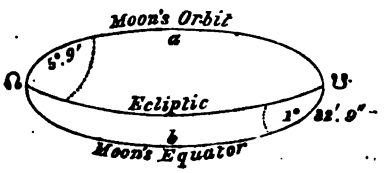
larger scale, in each of which there should be a point of the first order—being apparent, this Appendix contains a form of computation based on Encke's method, and modified from Lohrmann's and Beer and Mädler's works, and as libration enters as a necessary element into the calculation, it is preceded by an investigation of libration in latitude and longitude. For the MS. from which the greatest part of this investigation is taken I am indebted to A. C. Ranyard, Esq., of Cambridge. I must, however, remark that the formulæ are derived from the 'Berliner Astronomisches Jahrbuch für 1843.'

2. The investigation of libration consists of three parts, viz., that of the angle C, or the angle which the meridian passing through the middle of the moon's apparent disk makes with the circle of declination; that of libration in latitude and that of libration in longitude. The meridian passing through the middle of the apparent disk should be carefully distinguished from the first meridian on the moon's surface, from which all selenographical longitudes are reckoned both east and west.

3. It will greatly assist in the conception of libration if the following principles be borne in mind.

Three planes being supposed to pass through the moon's centre, viz. the plane of the moon's equator, the plane of her orbit, and a plane parallel to the plane of the ecliptic, the last will lie between the others, and will intersect them in the line in which they intersect each other.

Fig. 1.




In consequence of this law the longitude of the ascending node of the moon's equator on the ecliptic always differs by 180° from the longitude of the ascending node of the orbit. The inclination of the moon's equator to the ecliptic is 1° 32′ 9″, the inclination of the plane of the orbit is about 5° 9′.

*Investigation of the angle* C.

4. Conceive the moon's centre to be the centre of the celestial sphere. In

Fig. 2.

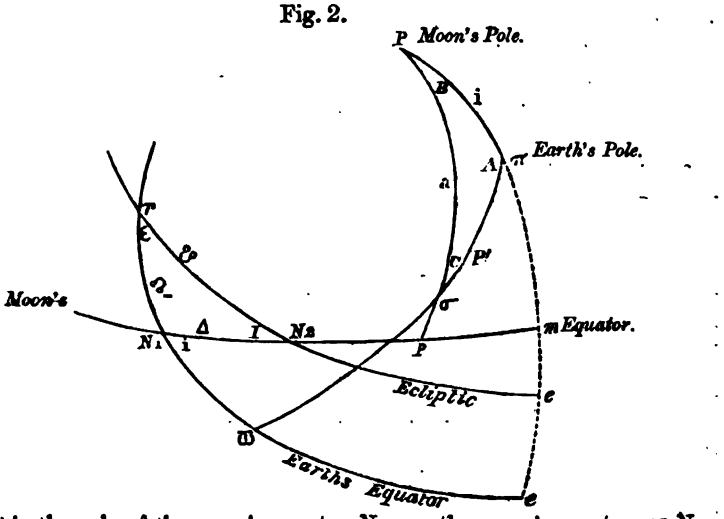



fig. 2, P is the pole of the moon's equator, $N_1 p m$ the moon's equator, $\Upsilon N_1 e$

is the great circle parallel to the earth's equator, $\pi$ its pole, $\Upsilon N_2 c$ is the great circle parallel to the plane of the ecliptic.

5. In the spherical triangle $\Upsilon N_1 N_2$ the angle $N_1 \Upsilon N_2 = \omega$ the obliquity of the ecliptic, the angle $\Upsilon N_2 N_1 = I$, the inclination of the moon's equator to the ecliptic, and $\Upsilon N_2 = \Omega$, the longitude of the ascending node of the moon's equator.

This last quantity is obtained by adding 180° to the longitude of the ascending node of the orbit given in p. 242 of the 'Nautical Almanac.' If the sum exceed a whole circumference, 360° must be subtracted.

6. Let the angle $N_2 N_1 e = i$, the inclination of the moon's equator to the earth's equator, which is equal to the arc $m e$ or $P\pi$.

7. Let $\Upsilon N_1 = \Omega'$, the distance from the first point of Aries of the ascending node of the moon's equator on the earth's equator, or the right ascension of the ascending node of the moon's equator on the earth's equator, and $N_1 N_2 = \Delta$, the arc between the two nodes on the moon's equator, or the arc on the moon's equator from its ascending node on the earth's equator to its ascending node on the ecliptic.

Then, by known formulæ in spherical trigonometry,

$$\tan A = \frac{\cos \frac{1}{2}(\omega - I)}{\cos \frac{1}{2}(\omega + I)} \tan \frac{\Omega}{2}, \quad \tan B = \frac{\sin \frac{1}{2}(\omega - I)}{\sin \frac{1}{2}(\omega + I)} \tan \frac{\Omega}{2},$$

$$\sin \frac{i}{2} = \frac{\sin \frac{1}{2}(\omega - I)}{\sin B} \sin \frac{\Omega}{2}, \quad \Delta = A + B, \quad \Omega' = A - B.$$

These are the formulæ for calculating the values of $i$ $\Delta$ and $\Omega'$ given on p. x of the 'Nautical Almanac.'

8. Let $\sigma$, fig. 2, be any point in the celestial sphere, of which the position is given by the selenocentric longitude $l$, reckoned from $\Upsilon$ to $N_2$, and then along the moon's equator to $p$, and by the selenocentric latitude, $\sigma p = \phi_1$. Also, let the coordinates of the same point referred to the plane parallel to the earth's equator be $\Upsilon \varpi = \alpha_1$, and $\varpi \sigma = \delta_1$, and let the angle $P \sigma \pi = C'$; then in the triangle $P \pi \sigma$, $P\pi = i$, $P\sigma = 90° - \phi_1$, $\pi\sigma = 90° - \delta_1$, the angle $\pi P \sigma = 90° - N_1 p = 90° - (N_2 p + N_1 N_2) = 90° - (l - \Omega + \Delta)$ $\{\because \Upsilon N_2 = \Omega\}$, and the angle $P \pi \sigma = 180° - \varpi e = 180° - (90° - N_1 \varpi) = 90° + N_1 \varpi = 90° + \alpha_1 - \Omega'$; $\{\because \Upsilon N_1 = \Omega'\}$. Hence

$$\frac{\sin C'}{\sin i} = \frac{\sin (90° - (l - \Omega + \Delta))}{\sin (90° - \delta_1)} = \frac{\cos (l - \Omega + \Delta)}{\cos \delta_1}, \text{ or}$$

$$\frac{\sin C'}{\sin i} = \frac{\sin (90° + \alpha_1 - \Omega')}{\sin (90° - \phi_1)} = \frac{\cos (\alpha_1 - \Omega')}{\cos \phi_1}.$$

9. The equations in section 8 relative to the angle C' are general, the point $\sigma$ not having been defined. If, however, we suppose that $\sigma$ and $\sigma_1$ represent those points on the moon's surface that are cut by the line joining the centres of the earth and moon, and that $\sigma$ is situated on the hemisphere turned towards the earth, $\sigma_1$ will be situated on the opposite or superior hemisphere. Now $\phi_1$ = the selenocentric latitude of the point $\sigma$, and this is equal to the selenocentric latitude of the centre of the apparent disk, as $\sigma$ is in the line joining the centres of the earth and moon, but this is equal to the geocentric latitude *with opposite signs*, i. e. if $b'$ = the moon's geocentric latitude $\phi_1 = -b'$.

In adapting the formulæ in section 8 to the position of $\sigma$, viz. towards the earth, let $\alpha'$ and $\delta'$ be the moon's apparent $R$ and N.P.D. corrected for parallax, then by the definition of the point $\sigma$, $\alpha_1 = 180° + \alpha'$, $\phi_1 = -b'$, $\delta_1 = -\delta'$, and $l = l + 180°$, $l$ differing from $\lambda$, the moon's geocentric longitude

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by a small angle found subsequently. These substitutions being made in the formulæ for sin C′, and changing C′ into C, we have

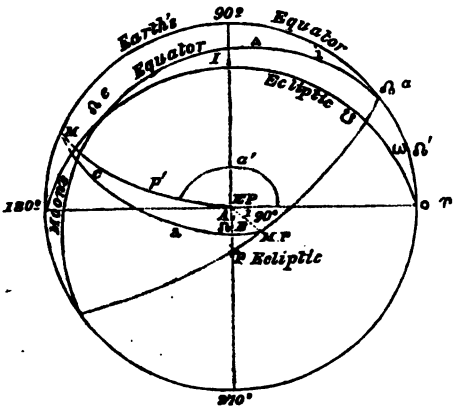
$$\sin C = -\sin i \cos\frac{(l-\mathfrak{S}+\Delta)}{\cos\delta'}$$
$$= -\sin i \frac{\cos(a'-\mathfrak{S}')}{\cos b'},$$

which are the formulæ on p. x of the 'Nautical Almanac' for computing the angle C.

10. The angle C changes sign with cos $(a'-\mathfrak{S}')$ and i, the change of sign of i being due to the motion of the moon's nodes. It does not change sign with the changes of sign of $\delta'$ and $b'$. It is positive when the northern part of the circle of declination is to the west of the moon's meridian.

11. In fig. 3, from Lohrmann, we have M P, the moon's pole; E P the

Fig. 3.




earth's pole; M the centre of the apparent disk; (M P) (E P)=i the inclination of the moon's equator to the earth's equator; (E P) M=$p'$, the N.P.D. of the moon's apparent centre $90°\pm\delta'$; (M P) M=a, the distance of the moon's apparent centre from the moon's pole=P $\sigma$, fig. 2, $=90°-\varphi_1$; the angle (M P) (E P) M=A the inclination of i to $p'=90°+a'-\mathfrak{S}'$ (see section 8), or $270°+\mathfrak{S}'-a'$ (see Lohrmann, 'Topographie der Sichtbaren Mondoberfläche,' p. 27); the angle (E P) (M P) M=B the inclination of i to $a=90°-(l-\mathfrak{S}+\Delta)$ (see section 8); the angle (E P) M (M P)=C the inclination of $p'$ to a (see section 8, angle P $\sigma\pi$=C′).

The formulæ for computing the angle A and the sides i and $p'$ are given above. The Gaussian formulæ for obtaining the values of B and C, with the side a are as follows:—

$$\tan\tfrac{1}{2}(B-C)=\frac{\cos\frac{1}{2}A\sin\frac{1}{2}(p'-i)}{\sin\frac{1}{2}A\sin\frac{1}{2}(p'+i)} \quad \ldots\ldots\ldots\ldots \quad (1)$$
$$\tan\tfrac{1}{2}(B+C)=\frac{\cos\frac{1}{2}A\cos\frac{1}{2}(p'-i)}{\sin\frac{1}{2}A\cos\frac{1}{2}(p'+i)} \quad \ldots\ldots\ldots\ldots \quad (2)$$
$$\tan\tfrac{1}{2}(B+C)=\frac{\cos\frac{1}{2}A\cos\frac{1}{2}(p'-i)}{\sin\frac{1}{2}A\cos\frac{1}{2}(p'+i)} \quad \ldots\ldots\ldots\ldots \quad (3)$$
$$\sin\tfrac{1}{2}a=\frac{\sin\frac{1}{2}A\sin\frac{1}{2}(p'+i)}{\cos\frac{1}{2}(B-C)} \quad \ldots\ldots\ldots\ldots \quad (4)$$

$$B=\tfrac{1}{2}(B+C)+\tfrac{1}{2}(B-C) \qquad C=\tfrac{1}{2}(B+C)-\tfrac{1}{2}(B-C),$$

These formulæ are employed in the following computations for determining the angle C and points of the first order.

*Investigation of Libration.*

12. In mapping the surface of the moon the orthographical projection is used in which the centre is characterized by 0° of latitude and 0° of longitude. This point, of course, is that in which the moon's equator and first meridian intersect each other. We have consequently to deal with *two points*, $\sigma$ or the centre of the apparent disk, which is the only point recognized in the computations of libration, and the point of intersection of the first meridian and the equator. These points coincide only when the line joining the centres of the earth and moon passes through the centre of the apparent disk in mean libration, which occurs in periods of 2·997 years.

13. At any other epoch than that of mean libration the point $\sigma$ is removed more or less from the point of intersection of the equator and first meridian, consequently as $\sigma$ is the only point of the moon's surface turned towards the earth to which the computations of libration refer, libration in latitude=the selenographical latitude of the apparent centre, and libration in longitude= the selenographical longitude of the same point.

14. When the moon passes the ascending node as seen from the centre of the earth, the moon's equator appears as a straight line on the apparent disk, and may be thus represented on the orthographical projection. Libration in latitude then=0°. As the moon passes from the ascending node to the greatest north latitude, the southern parts of the moon come into view, and the equator is projected on the apparent disk as the lower segment of a narrow ellipse, as given in an inverting telescope. All the appearances described in this Appendix are inverted, lower for upper, &c. The east limb or margin of the moon is seen in the telescope opposite to the right hand. The greatest libration in latitude = the moon's latitude + the inclination of the moon's equator to the ecliptic *a b*, fig. 1, p. 223. Were the moon a transparent globe and the equator marked on it, the equator would be seen as a long, narrow ellipse, widening and closing up between the passages of the nodes, so that at the passage of the descending node the libration is again = 0°.

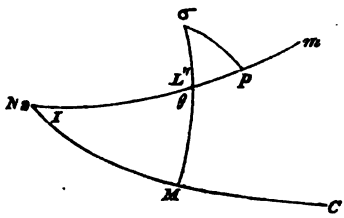
Fig. 4.

The same phenomena take place as the moon describes the portion of her orbit south of the plane of the ecliptic, but in the opposite sense, the northern parts coming into view. From this it will be seen that libration in latitude changes its sign every lunation at the passages of the nodes.

15. To calculate the librations of the centre of the apparent disk, it will be necessary, first, to determine the selenocentric coordinates of the point $\sigma$, as referred to the great circle $\Upsilon\ N_2 c$, fig. 2, parallel to the plane of the ecliptic.

In fig. 5 let the angle at $N_2 = I$, the inclination of the moon's equator to the ecliptic, $N_2 m$, as before, fig. 2, representing an arc of the moon's

Fig. 5.




equator, and $N_2 C$ ($c$ fig. 2) an arc of the ecliptic. As the arc $N_2 M$ is the projection on the ecliptic of the arc subtending the angle at the moon's centre, contained between a line parallel to the nodal line and the line joining the centres of the earth and moon, it must be equal to the difference of the geocentric longitude of the moon and the longitude of the ascending node of the moon's equator $\Omega$. Let $\therefore$ $\lambda$ be the moon's geocentric longitude, then $N_2 M = \lambda - \Omega$. Let $A'$ be an arc measured from $\Upsilon$ to $N_2$, fig. 2, and then from $N_2$ to $L''$, fig. 5, so that $N_2 L'' = A' - \Omega$, and $L'' p = l - A'$ { $\because$ $l$ is also measured from $\Upsilon$}. Also let $L'' M = B'$, the arc subtended between the moon's equator and the ecliptic, of which the greatest value $= 1° 32' 1''$, and the angle $N_2 L'' M = \theta$, the inclination of $A' - \Omega$ to $B'$; then by the right-angled spherical triangle $L'' N_2 M$ we have

$$\tan (A' - \Omega) = \tan (\lambda - \Omega) \sec I,$$
$$\tan B' = \sin (\lambda - \Omega) \tan I,$$
$$\cos \theta = \cos (\lambda - \Omega) \sin I = a', \text{ in the 'Nautical Almanac,'}$$
$$\sin \theta = \frac{\cos I}{\cos B'}, \text{ and by the right-angled spherical triangle}$$

$L'' \sigma p$, putting $\beta$, the geocentric latitude of the centre, for $\sigma$ M,

$$\tan (l - A') = \cos \theta \tan (\beta - B'),$$
$$\sin \phi_1 = \sin \theta \sin (\beta - B').$$

*Formulæ for Libration in Latitude.*

16. Libration in latitude, or the selenographical latitude of the centre of the apparent disk, is equal to the angle subtended between the point $\sigma$, the centre of the apparent disk, and the point $p$ the abscissa on the moon's equator, to which it is referred, so that $\sigma p$ is equal to the perpendicular dropped from the centre of the apparent disk upon the moon's equator. This angle is equal to the distance of the moon's apparent centre from the moon's pole, minus 90°, and is consequently equal to 0° when the moon is in either node.

17. As $-b' = \phi_1$ (see section 9), it follows that $b' = B' - \beta$, for $\phi_1$, or $\beta - B'$ (i. e. $\sigma p$), is the libration in latitude apart from its sign. As $\phi_1$ is positive when the point $\sigma_1$ (see section 9) is above the moon's equator (for which $l_1 = \lambda$ nearly), it will in the same case be negative for the point $\sigma$ (see section 9) (for which $l_1 = \lambda + 180°$ nearly), but in the case supposed the libration in latitude is *negative*; hence if $b' =$ this libration, $b' = -\phi_1 = B' - \beta$, which is the expression in the 'Nautical Almanac.'

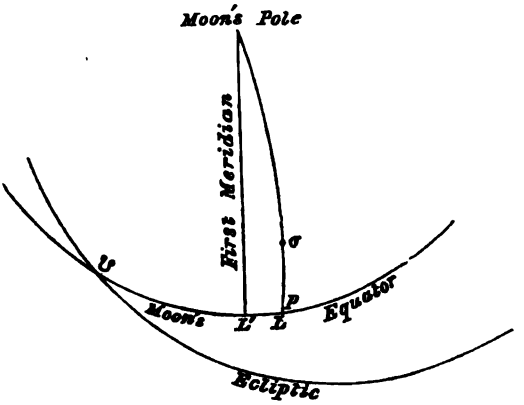
Lohrmann (Topographie der Sichtbaren Mondoberfläche, p. 27) gives $b' = (a - 90°)$, a being equal to the distance of the moon's apparent centre from the pole (see section 11). This formula is employed in the following computations for determining points of the first order.

Since the greatest value of B′ is about 1° 32′, and the greatest value of $\beta$ about 5° 5′, it follows that $b'$ must change sign in each lunation (see section 14).

*Investigation of Libration in Longitude.*

18. Libration in longitude, or the selenographical longitude of the apparent centre of the disk, is equal to the angle formed at the moon's pole between the first meridian, or that from which all selenographical longitudes are reckoned, and the circle of latitude (Moon's pole $\sigma$ p L in fig. 6) passing through the apparent centre of the disk. This angle is equal to the

Fig. 6.



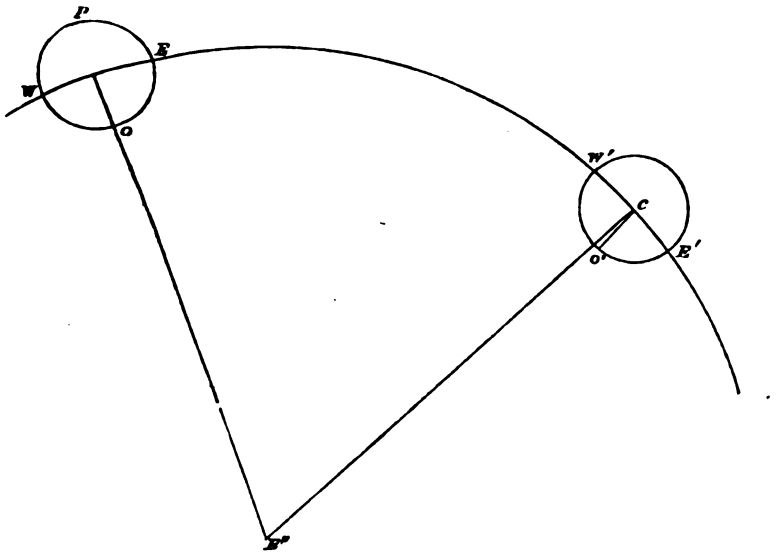

selenocentric longitude of the apparent centre of the disk, reckoned on the moon's equator from the ascending node of the moon's equator on the ecliptic (which is equal to the longitude of the ascending node of the orbit + 180°), minus the distance of the first meridian from the same point (see fig. 6), where ☊ (N, fig. 2, p. 223) represents the ascending node of the moon's equator on the ecliptic, L the selenocentric longitude of the apparent centre $\sigma$, and L′ the distance of the first meridian from ☊, or its selenocentric longitude. The distance of the first meridian from the ascending node of the moon's equator on the ecliptic is, from the uniformity of the moon's rotation, at all times equal to the moon's mean longitude, minus the longitude of the ascending node of the orbit, or plus the supplement of the longitude of the ascending node. Libration in longitude vanishes when the moon is in the line of the apsides.

19. When the moon passes the point of perigee, the first meridian, 0°, of selenographical longitude appears as a straight line, which cuts the centre of the apparent disk. Libration in longitude then = 0°. Should the passage of the perigee coincide with that of either node, the first meridian is projected at right angles to the equator, also a straight line; and the apparent disk is in a state of mean libration, and may be represented on the orthographical projection, subject to the necessary distortion in the regions about the limb.

The distortion on the orthographical projection arises from the greater foreshortening of objects near the limb, as seen from the earth, than the true orthographical projection will represent.

20. During the passage of the moon from perigee, at which point her motion is quickest, to apogee, where it is slowest, the motion in her orbit is *slower* from day to day, while her motion in rotation continues uniform; the consequence is, that while passing from perigee to mean distance the first meridian is transferred eastwardly (see fig. 7), which is inverted, where E'' represents the earth, W P E *o* the moon's equator when she is in perigee, *o* being its intersection with the first meridian, W' *o'* E' the segment of the

Fig. 7.




moon's equator presented to the earth at a given distance from perigee, *c o'*. a radius from the moon's centre to the first meridian, the angle E'' *c o'*= the quantity gained by the axial over the orbital motion=the difference between the moon's true and mean longitudes nearly=libration in longitude, by which the western portions come into view, and the first meridian

Fig. 8

is projected as a curve east of the centre of the apparent disk. At the point of mean distance the two motions coincide in value, but only momentarily so, the greatest libration towards the east is attained, the orbital motion becomes slower than the axial, and the first meridian returns westwardly, attaining its mean position at the passage of the apogee. In consequence of the small difference of the period of the revolution of the apsides and half that of the nodes, the equator will not appear as a straight line across the apparent disk, when the first meridian returns to its mean position, and therefore the point of 0° latitude will not be found at the centre of the apparent disk; the divergence will be greater at the end of every period either of the passage of the nodes or apsides, increasing for a period of about eighteen months, after which the divergence will decrease during another period of eighteen months, and at the end of three years (nearly) the state of mean libration will be again attained.

Libration in longitude from apogee to perigee is the opposite to that above described, from which it follows that libration in longitude changes sign every lunation.

21. The mathematical portion of this investigation may be treated under *two* heads, viz., the method adopted in the 'Nautical Almanac,' and that adopted by Lohrmann. For the method adopted in the 'Nautical Almanac' we again refer to fig. 5, the reasoning being as follows:—

Since I is a very small angle, the equation $\tan(A'-\varpi)=\tan(\lambda-\varpi)\sec I$ (see section 15) gives by a known formula of expansion $A'=\lambda+\sin 2(\lambda-\varpi)\tan^2\frac{I}{2}$, the rest of the terms being insignificant. The second term is $\Delta\lambda$ in the 'Nautical Almanac.' Because I is very small, and B′ is always less than I, $\sin\theta$ or $\frac{\cos I}{\cos B'}$ will be very nearly = to unity. Also because $l-A'$, $\phi_1$, and $\beta-B'$ are all small arcs, we may substitute the arcs for their tangents and sines. Hence

$$l-A'=\cos\theta\,(\beta-B)=a'\,(\beta-B') \text{ and } \phi_1=\beta-B';$$

consequently

$$l=\lambda+\sin 2(\lambda-\varpi)\tan^2\frac{I}{2}+\frac{\phi_1}{\frac{1}{a'}}$$

$$=\lambda+\Delta\lambda+\frac{\phi_1}{\frac{1}{a'}};$$

and as the libration in longitude $l'=l-l_0$, where $l_0$=the moon's mean longitude, the libration in longitude $=\lambda+\Delta\lambda+\frac{\phi_1}{\frac{1}{a'}}-l_0$; but since, as mentioned in section 9, $-b'$ is to be substituted for $\phi_1$, the expression becomes $l'=\lambda+\Delta\lambda-\frac{b'}{\frac{1}{a'}}-l_0$, as in p. x of the 'Nautical Almanac.'

22. Lohrmann, whose symbol for the moon's mean longitude is l, and for the libration in longitude is l′, gives, in 'Topographie der Sichtbaren Mondoberfläche,' p. 28, the following formula for computing the libration in longitude: $l'=L-L'$ (see section 18 and fig. 6). Now $L=270°+B-\Delta$ and

L′=l+supp. ☊ (see section 18). For the formulæ used in computing B see section 11, and for Δ see section 7. These formulæ have been employed in the following computations of points of the First Order.

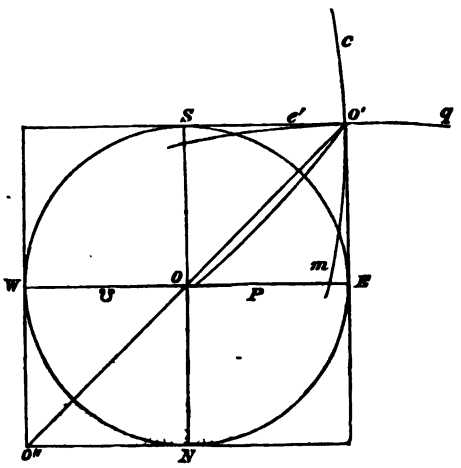
The principal part of the libration in longitude is $l-\lambda$ (see section 9), which, besides changing sign in each lunation with respect to east and west, changes sign also with respect to north and south by the motion of the moon's apsides.

*Application of the foregoing investigations to the motion on the apparent disk of the point at which the Equator intersects the First Meridian.*

23. It now remains to inquire how the point of intersection of the moon's equator and first meridian will be affected by the changes in latitude and longitude which the centre of the apparent disk is perpetually undergoing; for as only the latitude and longitude of this single point are determined by the formulæ for computing the librations, we do not appear to have at present the means for tracing out on the moon's disk the curves representing the moon's equator and first meridian for any other epochs than that of mean libration, when, as before mentioned, they cross the disk in two straight lines intersecting at the centre; and this inquiry is perhaps the more important as showing how necessary it is, for accurately mapping the surface, to have good determinations of points of the first order. Taking, therefore, the spot on the moon's surface at which the equator and first meridian intersect each other, we may inquire the path it will describe on the apparent disk during the changes of libration through one revolution of the nodes.

24. In fig. 9 let W E N S represent a small circle concentric with the limb or margin of the apparent disk of the moon, W E being a portion of the equator,

Fig. 9.

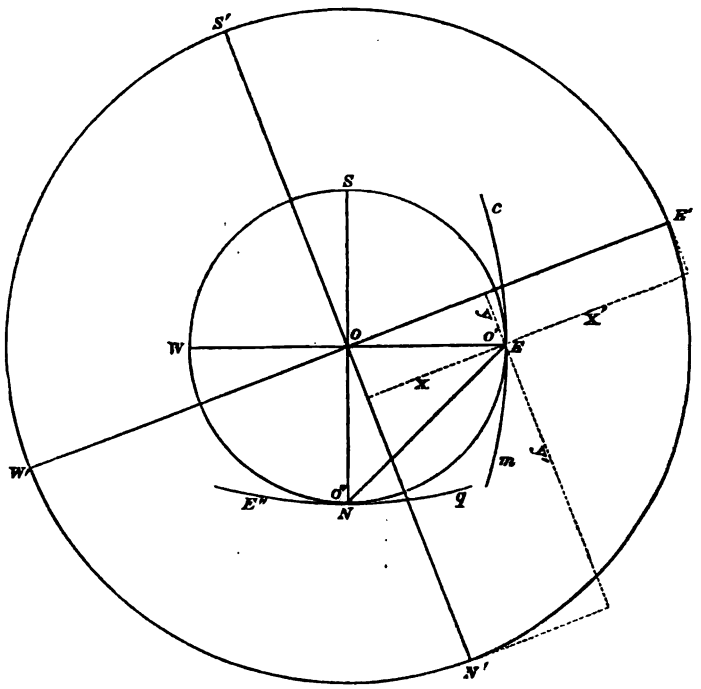



and N S of the first meridian in mean libration at the passage of the descending node and perigee respectively, and $o$ the point of intersection of the two (0° of latitude and longitude), and $o'$ the position occupied by the point $o$ by the joint effect of both librations, $o$ E will consequently represent the greatest excursion of the point $o$ in longitude, and $o$ S that in latitude, the equator being projected in the curve $e'o'q$, and the first meridian in $co'm$. The

displacement of $o$ being in the line $o\,o'$, the libration of the centre of the apparent disk $\sigma$ will be W in longitude and N in latitude. It is easy to see that the path of the point of intersection of the equator and first meridian, a short time before and after the epoch of mean libration, will be in a very narrow ellipse, the line $o'\,o''$ being the major axis, which does not, however, retain its position on the apparent disk, but revolves around the central point.

25. This ellipse opens out and undergoes changes of form proportional to the interval elapsing from the epoch of mean libration until the epoch when the greatest excursion of libration in longitude towards the east (of the point of intersection of the equator and the first meridian) coincides with the passage of the ascending node when the equator is represented as a straight line across the apparent disk and the first meridian by the curve $c\,\mathrm{E}\,m$ in fig. 10,

Fig. 10.




where the libration of the centre of the apparent disk is nothing in latitude, but west in longitude. When the first meridian returns to its normal position, the equator is represented by the curve $\mathrm{E}''\,\mathrm{N}\,q$ (fig. 10), and the point of intersection is situated at $o''$ (nearly); the libration of the centre in this case is nothing in longitude but south in latitude.

26. At this epoch, intermediate between two of mean libration, the path of the point of intersection of the equator and first meridian may be represented by the four diagonals, of which $o'\,o''$ (fig. 10) is one, or, perhaps more correctly, by a wavy ellipse; for as the values of the two librations differ in amount, the circle W E N S is not a true representation of the excursions of the intersecting point E and W, N and S; so when the greatest deviation

from mean libration occurs, the real path of the intersecting point on the apparent disk is a wide ellipse, which gradually contracts to a narrow ellipse as the epoch of mean libration is approached. This will be the case proportionally with every point on the apparent disk, and the displacement will be in every possible direction and at every conceivable angle with the centre of the apparent disk. This suggests that by far the most effective mode of determining positions on the moon's surface is by measures for points of the first order; for let x' y' represent the measures in right ascension and declination from the east and north limbs of the point E, x and y will be the corresponding rectangular coordinates necessary to determine the selenographical position when the librations of the centre and the other elements are ascertained.

### Computation of Points of the First Order.

#### *Measures.*

In order to compute the selenographical coordinates of a point on the moon's surface (its latitude and longitude), the following measures are necessary:—

Between five and ten measures of the distance of the point from the illuminated north or south limbs; also from the illuminated east or west limbs as the case may be.

The moon's diameter in the direction of the line drawn through both cusps, which may be assumed perpendicular to the ecliptic as the moon seen from the sun, departs at the utmost only 50″ from the plane of the ecliptic.

These measures require to be corrected for refraction according to the following formulæ.

The measured diameter in micrometer revolutions, which call D, is to be multiplied by the factor $\left(1+\frac{\cos^2 n' dr}{600}\right)$, in which $n'$ = the angle which the line of the cusps makes with the vertical circle passing through the moon, $dr$ = the difference of refraction in seconds for 10′ in the altitude of the moon (within the narrow space of the moon's disk the difference of refraction may be assumed proportional to the difference of altitude); $dr$ may be taken from the 'Connaissance des Temps.'

The formulæ for correcting the measured distances (also in micrometer revolutions) of the point from the moon's limbs are as follows:—

In the declination circle,

$$\frac{\Delta h \,.\, dr \,.\, \cos n}{25{\cdot}12 \times 10},$$

in the parallel,

$$\frac{\Delta h' \,.\, dr \,.\, \sin n}{25{\cdot}12 \times 10};$$

$n$ representing the inclination of the apparent declination circle to the vertical circle passing through moon's centre, and $\Delta h$, $\Delta h'$ the differences of altitude of the measured point and the tangents at the respective limbs. When southerly the correction is + for heights and − for depths, and the reverse when northerly.

Having obtained these measures and corrected them, the following elements for the time of observation should be taken from the 'Nautical Almanac.'

#### *Elements.*

$\alpha$ = the true right ascension of the moon.

$\delta$ = the true declination of the moon.

$\pi$ = the moon's equatoreal horizontal parallax.
R = the moon's true semidiameter in seconds.
The following elements, already computed, will be found in the 'Nautical Almanac,' page 491, year 1867; 489, year 1868; 490, year 1869; 493, year 1870.
i = inclination of the moon's equator to the earth's equator.
$\Delta$ = arc of the moon's equator from its ascending node on the earth's equator to its ascending node on the ecliptic.
$\Omega'$ = $\mathcal{R}$. of the ascending node of the moon's equator on the earth's equator.
l = moon's mean longitude.
For the formulæ see *ante*, sect. 7, p. 224.
In addition,—
$\rho$ = log of earth's radius at the place of observation.
$\phi'$ = latitude of the place of observation corrected for the spheroid.
$\vartheta$ = sidereal time of observation converted into arc.

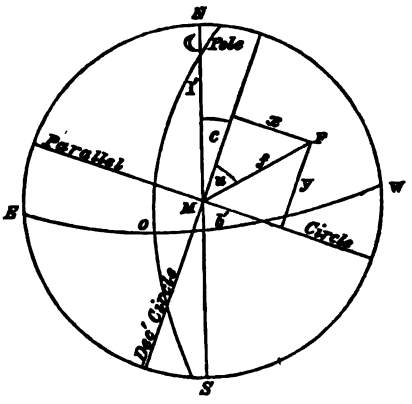
*Example.*

Taking Lohrmann's example, we have, 1823, October 22, $0^h\ 35^m\ 15^s$, true time Dresden,

| | |
|---|---|
| Theophilus from the N. limb..... | 48·32 |
| ,, ,, E. ,, ..... | 55·61 |
| Moon's semidiameter ..... | 38·79=R', |

all in micrometer revolutions corrected for refraction.

Fig. 11.




In fig. 11 let F be the measured point, then $x$= the coordinate in the parallel, and $y$= the coordinate in the declination circle. Accordingly,

$$x = +16^r{\cdot}82, \quad y = -9^r{\cdot}53.$$

The values of the above-named elements at the time of observation were as under:—

| | | | |
|---|---|---|---|
| $\alpha$ = | 50° 44′ 54″ | i = | 22° 55′ 34″ |
| $\delta$ = | +22 59 22 | $\Delta$ = | 109 38 6 |
| $\pi$ = | 0 58 48 | $\Omega'$ = | 3 30 36 |
| R = | 0 16 1 | l = | 57 35 1 |

Latitude 51° 3′ 0″ N., longitude 0ʰ 45ᵐ 40ˢ E. of Paris Observatory, from whence

$\phi' = 50^\circ\ 51'\ 53''$

$\log \rho = 9{\cdot}9991353$

$\log (\rho \sin \phi') = 9{\cdot}8888055$

$\log (\rho \cos \phi') = 9{\cdot}7992703$

$\mathfrak{S} = 34\ 35\ 45$

*Parallax in Right Ascension and Declination.*

The next step is to obtain the apparent right ascension and declination of the moon.

Also $p'$ = N.P.D. of moon's apparent centre $= 90 \pm \delta'$, $\delta'$N, $-\ \delta'$S, +

A = inclination of i to $p' = 90° - \mathfrak{S}' + \alpha'$, or

$= 270° + \mathfrak{S}' - \alpha'$.

Let $\alpha'$ = the moon's apparent right ascension;

$\delta'$ = the moon's apparent declination;

then for $\alpha'$ we have

$$\tan (\alpha' - \alpha) = \tan \alpha'' = \frac{\frac{\rho \cos \phi' \sin \pi}{\cos \delta} \sin (\alpha - \mathfrak{S})}{1 - \frac{\rho \cos \phi' \sin \pi}{\cos \delta} \cos (\alpha - \mathfrak{S})}, \quad \frac{\rho \cos \phi' \sin \pi}{\cos \delta} \cos (\alpha - \mathfrak{S}) = n.$$

$\alpha = 50^\circ\ 44'\ 54''$

$\mathfrak{S} = 34\ 35\ 45$

$(\alpha - \mathfrak{S}) = 16\ 9\ 9$

| | | | |
|---|---|---|---|
| $\log \rho \cos \phi'$ | 9·79927 | $\log \frac{\rho \cos \phi' \sin \pi}{\cos \delta}$ | 8·06829 |
| $\log \sin \pi$ | 8·23308 | $\log \cos (\alpha - \mathfrak{S})$ | 9·98251 |
| ar. co. $\log \cos \delta$ | 0·03594 | sum $= \log n$ | 8·05080 |
| sum = | 8·06829 | $n$ | 0·01124 |
| $\log \sin (\alpha - \mathfrak{S})$ | 9·44434 | $(1 - n)$ | 0·98876 |
| ar. co. $\log (1 - n)$ | 0·00491 | | |
| sum $= \log \tan \alpha''$ | 7·51754 | | |

| | | |
|---|---|---|
| $\alpha''$ | + | $0^\circ\ 11'\ 19''$ |
| $\alpha$ | | $50\ 44\ 54$ |
| sum $= \alpha'$ | | $50\ 56\ 13$ |

For $\delta'$ we have

$$\tan \delta' = \frac{\tan \delta - \frac{\rho \sin \phi' \sin \pi}{\cos \delta}}{1 - \frac{\rho \cos \phi' \sin \pi}{\cos \delta} (\cos \alpha - \mathfrak{S})} \times \cos (\alpha' - \alpha), \quad \frac{\rho \sin \phi' \sin \pi}{\cos \delta} = k,$$

| | | | |
|---|---|---|---|
| $\log \rho \sin \phi'$ | 9·88880 | $\log (\tan \delta - k)$ | 9·61266 |
| $\log \sin \pi$ | 8·23308 | ar. co. $\log (1 - n)$ | 0·00491 |
| ar. co. $\log \cos \delta$ | 0·03594 | sum $= \log \tan \delta'$ | 9·61757 |
| sum $= \log k$ | 8·15782 | $\delta'$ | $22^\circ\ 30'\ 58''$ |
| $\tan \delta$ | 0·42426 | $p' = 90° - \delta'$ | $67\ 29\ 2$ |
| $k$ | 0·01438 | | |
| diff. $= \tan \delta - k$ | 0·40988 | $\alpha' + 90°$ | $140^\circ\ 56'\ 13''$ |
| | | $\mathfrak{S}'$ | $3\ 30\ 36$ |
| | | A | $137\ 25\ 37$ |

*Librations of Centre.*

Having found the apparent right ascension and declination of the moon, also the apparent N.P.D. of the centre, and the angle A, we proceed to compute the following quantities:—

1′ = the selenographical longitude of the apparent centre = libration in longitude*.

b′ = the selenographical latitude of the apparent centre = a − 90° = libration in latitude†.

C = the angle which the meridian of the middle of the moon's disk makes with the declination circle. See section 4 *et seq.*, and figs. 3 and 11.

For the formulæ see section 11.

*Angle* C *and* b′.

| | | | |
|---|---|---|---|
| ½i | 11° 27′ 4″ | ½(p′−i) | 22° 16′ 44″ |
| ½p′ | 33 44 31 | ½(p′+i) | 45 12 18 |
| ½A | 68 42 48·5 | | |

| | | | |
|---|---|---|---|
| log cos ½A | 9·55996 | log sin ½A | 9·96931 |
| log sin ½(p′−i) | 9·57877 | log sin ½(p′+i) | 9·85103 |
| sum (1) | 9·13873 | sum (2) | 9·82034 |
| sum (2) | 9·82034 | | |
| diff. = log tan ½(B−C) | 9·31839 | | |
| log cos ½A | 9·55996 | log sin ½A | 9·96931 |
| log cos ½(p′−i) | 9·96630 | log cos ½(p′+i) | 9·84792 |
| sum (3) | 9·52626 | sum (4) | 9·81723 |
| sum (4) | 9·81723 | | |
| diff. = log tan ½(B+C) | 9·70903 | ½(B−C) | 11° 45′ 31″ |
| | | ½(B+C) | 27 5 59 |
| sum (2) | 9·82034 | B | 38 51 30 |
| log cos ½(B−C) | 9·99079 | C | −15 20 28 |
| diff. = log sin ½a | 9·82955 | ½a | 42 29 5 |
| | | a | 84 58 10 |
| | l′ | b′ | − 5 1 50 |

For the selenographical longitude of the moon's apparent centre, we have l′ = L − L′, where L = the selenocentric longitude of the moon's apparent centre, and L′ = 1 + supplement of ☊. See Section 22. Now

L = 270° − B − Δ, Sup. ☊ = 67° 8′ 20″

| | | | |
|---|---|---|---|
| | 270° 0′ 0″ | Δ | 109° 38′ 6″ |
| Δ+B | 148 29 36 | B | 38 51 30 |
| L = 270° − B − Δ | 121 30 24 | Δ+B | 148 29 36 |
| L′ = 1 + sup. ☊ | 124 43 21 | | |
| L − L′ = l′ | −3 12 57 | l | 57 35 1 |
| | | Sup ☊ | 67 8 20 |
| | | L′ | 124 43 21 |

* + when W. of the first meridian, − when E.

† + when N. of equator, − when S.

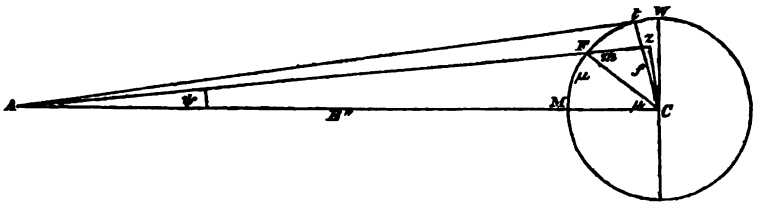
Collecting the results, we have

$$\begin{aligned} b' &= -\ 5\ 1\ 50 \\ l' &= -\ 3\ 12\ 57 \\ C &= -15\ 20\ 28 \end{aligned}$$

*Determination of the Arc $\mu$.*

Having determined the selenographical latitude and longitude of the apparent centre of the moon's disk, and also the angle which the meridian of the middle of the disk makes with the circle of declination, we may ascertain the latitude and longitude of the measured point by the aid of the arc $\mu$ (fig. 12) on the spherical surface of the moon, which connects the measured point with the apparent centre M.

Fig. 12.




For this object the following elements are required:—

Fig. 11, p. 234. $f$ = the polar coordinate of the measured point = sin $m$, fig. 12.

" " $u$ = the inclination of $f$ to the apparent declination circle.

For obtaining the values, we have

Fig. 11, p. 234, $f = \dfrac{y}{R' \cos u}$, $\quad \tan u = \dfrac{x}{y}$.

Fig. 12. $\mu = m - \psi$.

Fig. 12. E'' = the distance of the moon's centre, C, from the place of observation, A.

$$\frac{f}{E''} = \sin \psi.$$

For $\dfrac{1}{E''}$ we have

$$\frac{1}{E''} = \frac{R'' \sin \pi}{R\, 3{\cdot}663},$$

in which

R'' = the moon's apparent semidiameter, to be computed by the following formula:—

$$R'' = \frac{\cos a'' \dfrac{\cos \delta'}{\cos \delta} . R}{1 - \dfrac{\rho \cos \phi' \sin \pi}{\cos \delta} \cos (\alpha - \vartheta) = (1 - n)}.$$

The computation of the value of $\mu$ is as under:—

| | | | |
|---|---|---|---|
| $\log\cos\alpha''$ | 0·00000 | $\log x$ | 1·22583 |
| $\log\cos\delta'$ | 9·96557 | $\log y$ | 0·97909 |
| ar. co. $\log\cos\delta$ | 0·03594 | diff. $=\log\tan u$ | 0·24674 |
| $\log\sin\pi$ | 8·23308 | | |
| ar. co. $\log(1-n)$ | 0·00491 | $u$ | 60° 27′ 55″ |
| ar. co. $\log 3{\cdot}663$ | 9·43616 | | |
| sum $=\log\frac{1}{E''}$ | 7·67566 | $\log y$ | 0·97909 |
| $\log f$ | 9·69752 | ar. co. $\log\cos u$ | 0·30720 |
| sum $=\log\sin\psi$ | 7·37318 | ar. co. $\log R'$ | 8·41123 |
| | | sum $=\log f$ | 9·69752 |

| | |
|---|---|
| $m$ | 29° 53′ 23″ |
| $\psi$ | 0 8 7 |
| $\mu$ | 29 45 16 |

*Formulæ for and Calculation of* $\lambda$ *and* $\beta$.

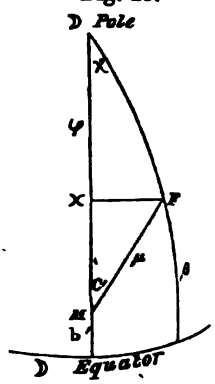
We are now in a position finally to determine $\lambda$ the selenographical longitude, and $\beta$ the selenographical latitude of the measured point by the aid of the following angles, C′, $\lambda''$, and $\chi$ (see fig. 13) for $\lambda=\lambda''+l'$, and $\tan\beta=\cos\lambda''\tan(\chi+b')$.

$C'=u+C=$ the inclination of the plane of the arc $\mu$ to the apparent latitude circle of the moon (see fig. 11, p. 234).

$$\tan\chi=\tan\mu\cos C',\quad \tan\lambda''=\frac{\tan C'\sin\chi}{\cos(\chi+b')},$$

$\lambda''+$ when W$-$ when E, $\chi+$ when C′ is N, $-$when C′ is S.

Fig. 13.




*Computation.*

| | | | |
|---|---|---|---|
| | $u$ | 60° 27′ 55″ | |
| | C | 15 20 28 | |
| sum $=$ | C′ | 75 48 23 | in 4th Quadrant. |
| $\log\tan\mu$ | 9·75713 | $\log\tan C'$ | 0·59701 |
| $\log\cos C'$ | 9·38952 | $\log\sin\chi$ | 9·14243 |
| sum $=\log\tan\chi$ | 9·14665 | ar. co. $\log\cos(\chi+b')$ | 0·01130 |
| $\chi$ | 7° 58′ 45″ | sum $=\log\tan\lambda''$ | 9·75074 |
| $b'$ | 5 1 50 | $\lambda''$ + | 29° 23′ 34″ |
| sum $=\log(\chi+b')$ | 13 0 35 | $l'$ − | 8 12 57 |
| $\log\tan(\chi+b')$ | 9·36370 | $\lambda$ + | 26 10 37 |
| $\log\cos\lambda''$ | 9·94016 | $\beta$ − | 11 22 55 |
| sum $=\log\tan\beta$ | 9·30386 | Therefore | |

Theophilus is situated in 26° 10′ 37″ W. long.
and 11 22 55 S. lat.

## Appendix III.

1st. Description of Map and Instructions for observing.

2nd. A catalogue of objects photographed and observed in areas IV $A^{\alpha}$ and IV $A^{\zeta}$.

3rd. The full-moon aspect of areas IV $A^{\alpha}$ and IV $A^{\zeta}$.

4th. A discussion of the lines of upheaval and depression in areas IV $A^{\alpha}$ and IV $A^{\zeta}$.

### British Association Outline* Map of the Moon, Zones II and IV, Areas IV $A^{\alpha}$ and IV $A^{\zeta}$.

The present portions of the map include areas IV $A^{\alpha}$, IV $A^{\zeta}$ and parts of IV $A^{\beta}$ and IV $A^{\eta}$; they are in outline on a scale 200 inches, equal to the moon's diameter. On these portions upwards of 200 objects are distinctly specified, and, as indicated below, their relative degrees of visibility pointed out. The scale of 200 inches to the moon's diameter appears to be the *smallest* that can be used with advantage in the present state of selenography. It allows every facility for inserting synonyms as well as various numerical data, also for exhibiting with clearness the relative position of each object. In some few instances objects, the precise nature of which is doubtful, are inserted without a numerical reference, and some mentioned in the catalogue are omitted, as their outlines require careful determination. In the spaces more or less blank there are small objects which await insertion when they have been observed with adequate power, and their relative positions ascertained. Without doubt much of the outline requires *modification*, as it is difficult to catch in the small intervals afforded for observation that correctness in form and outline which is desirable, and instances of fine definition in which it might be attained are rare, and occur at varying states of libration, and at different degrees of illuminating and visual angle: while, however, much may be achieved by the aid of photography, yet the evident relief indicating heights and depths, and the diversity of light, shade, and *shadow* interfere to no little extent in forming a judgment of the true outline, especially as no two photographs are likely to exhibit the same object under similar circumstances; still it is hoped the following catalogue of objects on areas IV $A^{\alpha}$ and IV $A^{\zeta}$, and the map will be mutually intelligible, and contribute to a closer study of the moon's surface, if it be only to detect the errors in either.

These portions of the map, as well as the accompanying catalogue, contain all the known objects, 202 on an area of 50 superficial degrees, as shown in existing photographs, and ascertained by personal observation. They are issued with the twofold view of assisting observers in becoming acquainted with the physical aspect, and also for enlarging the boundary of our knowledge of the moon's surface. They are printed *red* that observers may the more readily insert additions and corrections in *black*.

The basis of the map, as well as the principle upon which it is constructed, is fully explained in the Report presented to the British Association at its Meeting held in Nottingham, 1866; it may, however, be important to mention that all positions, except those of the first order, are derived from Mr. De la Rue's photograph of October 4, 1865, which was taken so near the time of Mean Libration, that the coincidence of the Equator of the photograph with that of the moon is sufficiently close to allow of direct mea-

* This map is not intended to be a perfect or complete Lunar Map, but only a guide to observers in obtaining data for the construction of a complete map.

sures of every object on the photograph. In the case of the first meridian, a small correction has been applied. The points of the first order, which are most scrupulously regarded, are found in Appendix I. of the above-named Report. In laying down those in quadrant IV., the greatest error discovered in checking them amounted only to ·0008, the moon's semi-diameter being equal to unity.

The following abbreviations are employed on the Map.

The Arabic numerals, except in cases of measurement, refer to the area of twenty-five superficial degrees indicated—and in quoting to be preceded—by the symbol of the area (see Brit. Assoc. Report, 1865, p. 288).

The small Greek letters refer to the *same* objects indicated by them on Beer and Mädler's Map of 37 inches diameter. The Roman capitals and small letters preceded by B. & M. are of similar import.

| | | |
|---|---|---|
| | . | Points of the first order. |
| | × | Points of the second order. |
| | o | Craters. |
| | ⌣ | Depressions. |
| | ∧ | Mountains. |
| | ∨ | Valleys. |
| N.B. The arrow-head is directed towards the lowest point. | ⌄ | Mountain slopes and valley sides. |
| | ⁂ | Very conspicuous objects. |
| | * | Easy objects. |
| | † | Difficult objects. |
| | ‡ | Objects rarely visible. |
| | B. & M. | Beer and Mädler. |
| | L. S. | Lohrmann's Sections. |
| | L. M. | Lohrmann's Map. |
| | S. R. | Schmidt's Rills. |
| | Eng. ft. | English feet. |
| | —— | Metres. |

Dotted lines in some instances indicate the bases of mountains, the crests being shown by continuous lines, also the lowest parts of valleys; in others the interior feet of crater slopes as *in* Halley, where the dotted line points out the base of the interior E. slope, in others lucid markings or streaks which require further observation.

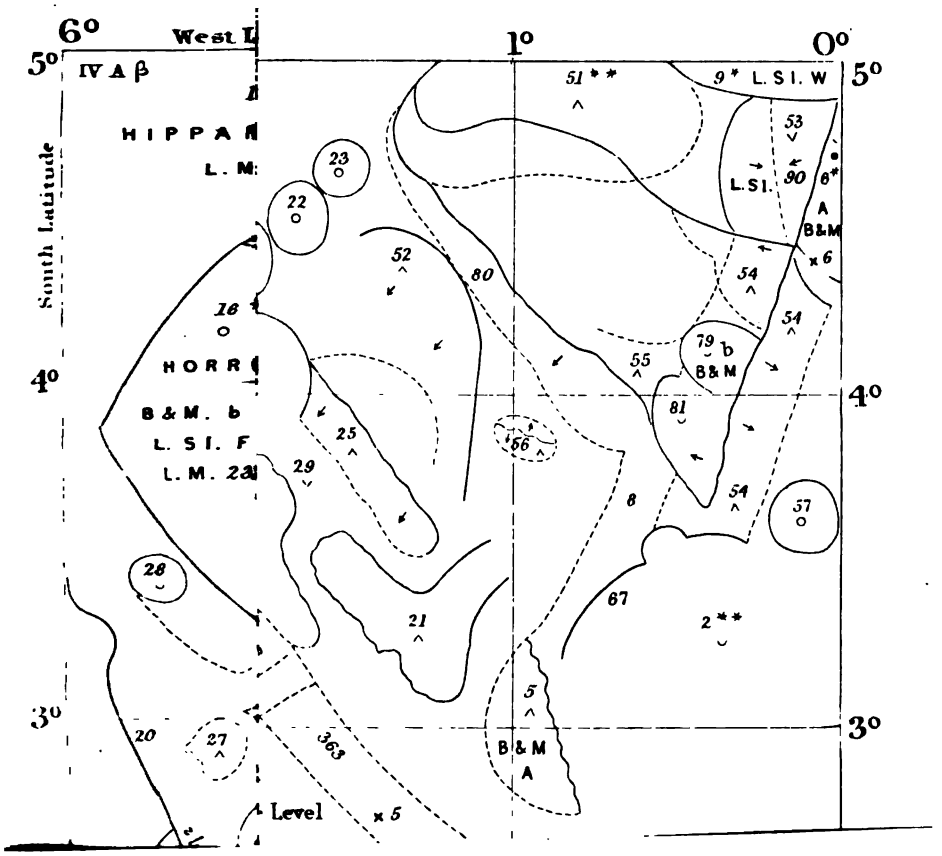
Some attempt has been made to indicate differences of level by inscribing on the map the words "high level," "higher level," "lower level," and "low level;" thus the level S. of Halley is very much higher than that of the floor of Hipparchus N. of Halley, and that of Albategnius marked "low level" is the lowest; the words higher and lower being comparative *between* high and low. This difference of level is brought out in a very marked manner by an oblique illumination.

The space between every 5° of latitude north and south constitutes a zone numbered from I. to XXXVI. (see Report, 1865, pp. 288–290). For the employment of the map, each zone may be divided into five subzones of 1°; and if to every observer *two* were allotted, so that half of the area selected by each were to overlap half of the adjoining areas of two subzones, observations, additions, and corrections will be received from two independent observers. As it is very probable that in some instances observers may have but little previous acquaintance either with the aspect of the moon's surface as regards "detail" or with methods of observation, the following instructions for observing the objects, also for correcting and adding to the map and catalogue, are drawn up upon this probability. The

Plate IV

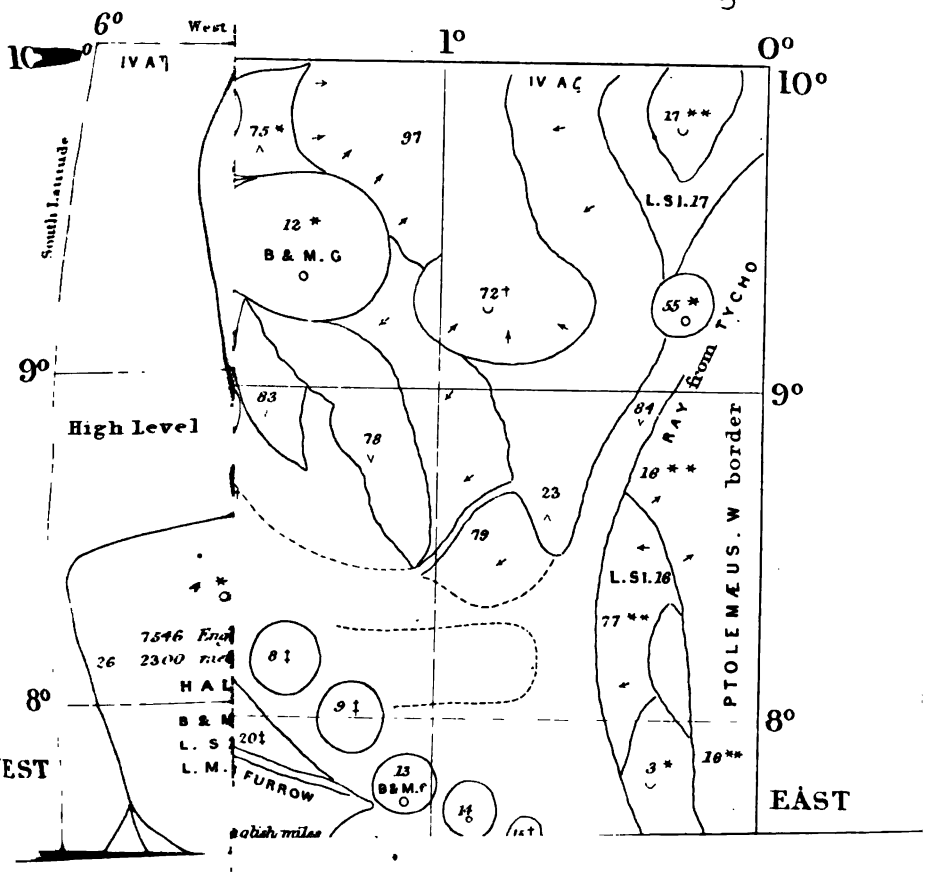
# LUN

## AREA IV A α



# LUNA

## AREA IV Aς



localities of IV $A^{\alpha}$ and IV $A^{\zeta}$ may be easily ascertained by reference to existing maps, the large formations, Hipparchus, Albategnius, and Ptolemæus, being sufficiently indicated.

The plate contains a portion from Beer and Mädler's map corresponding to areas IV $A^{\alpha}$ and IV $A^{\zeta}$. The small circle above on the same scale represents one degree at the centre of the disk in mean libration. The large circle below represents a similar area on the scale of 200 inches to the diameter, that of the British Association Outline Map. It contains 279·27 square miles (English), and is seen under an angle of $16''{\cdot}277 \pm$.

It is only at the centre of the disk that one degree is seen under an angle of $16''{\cdot}277$; in other parts of the disk the reduction is in the proportion of the angle subtended at the centre × cosine of the angular distance from the centre; thus at a distance of 12° from the centre, $16''{\cdot}277 \times \cos 12° = 15''{\cdot}922$, and at a distance of 60°, $16''{\cdot}277 \times \cos 60° = 8''{\cdot}139$.

The arrangement of subzones to each observer in zone II. area IV $A^{\alpha}$ is as follows:—No. 1, S. lat. 0° to 1°; No. 2, 0° to 2°; No. 3, 1° to 3°; No. 4, 2° to 4°; No. 5, 3° to 5°; and No. 6, 4° to 5° S. lat.: No. 6 of area IV $A^{\alpha}$ will be allotted to No. 1 of zone IV area IV $A^{\zeta}$, the numbers of which are as follows:—No. 1, S. lat. 5° to 6°; No. 2, 5° to 7°; No. 3, 6° to 8°; No. 4, 7° to 9°; No. 5, 8° to 10°; and No. 6, 9° to 10° S. lat.

The very high probability, if not certainty, that the crater "Linné" has undergone a physical change since it was first figured by Riccioli in 1653, induces the belief that if lunar objects were observed upon a regular system from time to time, other instances of *inferred* physical change may be detected, especially among the smaller features. With this view, the objects in each area of two subzones, arranged in the order of their visibility, as far as ascertained, are specified, that observers may have as little trouble as possible in selecting objects for observation.

The following numbers refer to the accompanying catalogue. Those marked with two asterisks (**) are conspicuous, those with one (*) are easy, those with a dagger are difficult (†), and those with a double dagger (‡) are very difficult, and but rarely seen. Nearly the whole of the objects recorded in area IV $A^{\zeta}$ have been observed with an aperture of $4\frac{1}{4}$ inches, object-glass by Cooke, power 230. The exceptions are mostly noticed. It is recommended that conspicuous objects should be examined first.

AREA IV $A^{\alpha}$.

No. 1. Lat. 0° to 1° S.—1**, 43, 46, 47, 49, 58, 59, 60, 65, 66, 68, 70, 72, 74, 85, 87.

No. 2. Lat. 0° to 2° S.—1**, 11, 15, 19, 38, 40, 43, 44, 45, 46, 47, 48, 49, 50, 58, 59, 60, 61, 62, 63, 64, 65, 66, 68, 69, 70, 72, 74, 77, 78, 84, 85, 87.

No. 3. Lat. 1° to 3° S.—2**, 10**, 4*, 5, 11, 15, 16, 19, 20, 31, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 48, 49, 50, 58, 61, 62, 63, 64, 65, 66, 69, 73, 77, 78, 83, 84, 86.

No. 4. Lat. 2° to 4° S.—2**, 10**, 4*, 5, 8, 11, 12, 13, 14, 16, 20, 21, 24, 25, 26, 27, 28, 29, 30, 31, 32, 34, 35, 36, 37, 38, 39, 41, 42, 49, 54, 56, 57, 67, 73, 77, 81, 82, 83, 86.

No. 5. Lat. 3° to 5° S.—2**, 10**, 51**, 6*, 7*, 9*, 18*, 3, 5, 8, 12, 13, 14, 17, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 42, 49, 52, 53, 54, 55, 56, 57, 67, 71, 73, 79, 80, 81, 82, 88, 75‡, 76‡.

No. 6. Lat. 4° to 5° S.—51**, 6*. 7*, 9*, 18*, 3, 17, 22, 23, 24, 28, 33, 34, 35, 49, 52, 53, 54, 55, 71, 79, 80, 81, 88, 75‡, 76‡.

### Area IV $A^{\zeta}$.

No. 1. Lat. 5° to 6° S.—47**, 24*, 49*, 58*, 11, 38, 39, 81, 96, 100, 101, 102, 103, 104, 105, 106, 111, 112, 113, 114, 85‡.

No. 2. Lat. 5° to 7° S.—47**, 24*, 28*, 37*, 49*, 56*, 58*, 60*, 61*, 11, 27, 38, 39, 46, 48, 57, 59, 80, 81, 85, 86, 96, 100, 101, 102, 103, 104, 105, 106, 108, 109, 110, 111, 112, 113, 114.

No. 3. Lat. 6° to 8° S.—1**, 4**, 6**, 7**, 16**, 25**, 29**, 3*, 26*, 30*, 31*, 37*, 49*, 56*, 60*, 61*, 11, 13, 14, 27, 44, 45, 46, 48, 57, 59, 80, 81, 86, 88, 92, 98, 99, 107, 108, 109, 110, 114. 2†, 15†, 18†, 19†, 21†, 22†, 9‡, 20‡, 62‡, 63‡, 64‡.

No. 4. Lat. 7° to 9° S.—1**, 4**, 5**, 6**, 7**, 16**, 25**, 29**, 33**, 77**, 3*, 30*, 31*, 32*, 37*, 43*, 61*, 65*, 13, 14, 23, 26, 27, 42, 44, 45, 54, 66, 78, 79, 83, 84, 88, 90, 91, 92, 93, 94, 95, 98, 99, 107, 2†, 15†, 18†, 19†, 21†, 22†, 76†, 89†, 8‡, 9‡, 20‡, 71‡, 62‡, 63‡, 64‡.

No. 5. Lat. 8° to 10° S.—5**, 16**, 17**, 25**, 33**, 34**, 36**, 67**, 77**, 10*, 12*, 32*, 43*, 52*, 55*, 65*, 75*, 23, 26, 35, 40, 41, 42, 50, 51, 53, 54, 66, 68, 69, 70, 73, 74, 78, 79, 82, 83, 84, 87, 90, 91, 93, 94, 95, 97, 99, 72†, 76†, 89†, 8‡, 9‡, 71‡.

No. 6. Lat. 9° to 10° S.—17**, 33**, 34**, 36**, 67**, 10*, 12*, 52*, 55*, 65*, 75*, 35, 40, 41, 42, 50, 51, 53, 68, 69, 70, 73, 74, 78, 82, 83, 87, 97, 72†.

#### Observations.

*Identification.*—The first step is to *identify* the objects in each pair of subzones, which may be best exemplified by the following record of observations for this purpose.

*Identification of Objects in Subzones No.* 3. Area IV $A^{\zeta}$.

1866, October 16, $7^h\ 15^m$ to $8^h\ 30^m$, G.M.T. No. 500. Day elapsed of the Julian Period (D. J. P.) 2402391, moon's latitude north 4° 54′ Apogee+$92^h$, Perigee −$201^h$, Royal Astronomical Society's Sheepshanks telescope, No. 5, $2\frac{3}{4}$-inch aperture, power about 150.

Definition good, terminator grazing east edge of Ptolemæus.

IV$A^{\zeta 1}$. Very conspicuous, but outline more circular.
4. Quite conspicuous.
6. Very conspicuous.
7. Quite conspicuous.
25. Its individual character and slight depression discernible, but this telescope appears to be unable to bring out its features strongly.
29. Quite easy; the spur is not so distinct.
3. Conspicuous, border illuminated, interior filled with shadow.
28. Just perceptible, but not very distinct.
30. Scarcely discernible.
31. Just perceptible.
13, 14 & 15. Not at all distinct, but some indications of the crater-row.
27. Just perceptible. It is not very striking, and would by no means arrest the attention with this aperture and power.
2. Not visible with this aperture nor power.
18, 19. Not visible with this aperture nor power.
21. Not visible with this aperture nor power.
22. Not visible with this aperture nor power.
9. Not visible with this aperture nor power; the shadows of IV$A^{\zeta 1}$ and IV$A^{\zeta 5}$ project slightly.

20. Not visible. There is, however, some indication of depression or excavation on the interior slope of IVA$^{\zeta 1}$, just south-west of the promontory stretching towards the crater-row 13–19.

In this manner every object may be sought for, and either identified, or if it be beyond the power of the telescope to show it, recorded as such, and so far as the pair of subzones extends, the capability of the telescope to reach only certain objects determined. These may be arranged—*for the telescope employed*—in classes of conspicuous, easy, difficult, very difficult, and invisible; and in thus becoming fully acquainted with the objects in the pair of subzones he has selected, the observer will find that he has employed his time to great advantage; indeed he will be surprised that, by regularly examining his portion to identify the objects already on record, he has become thoroughly acquainted with all the prominent features of the region.

In work of this kind the observer will find it very advantageous to examine his subzones under *similar* conditions of illumination, which recur roughly in periods of fifty-nine days, but more accurately in fifty-nine days eighty-eight minutes; and these periods will afford an interval of about eight months, during which, in every alternate month, should the sky be clear, he will see the objects similarly illuminated (very nearly). The numbers in the sixth column, headed "days elapsed of the Julian Period," on p. xx of each month in the Nautical Almanac, will facilitate the computation of these periods. Thus, if on January 13, 1867, at 6 P.M., he notices the Terminator or Light boundary to pass over any particular spot, 59$^{d}$ 1$^{h}$ 30$^{m}$ afterwards the Terminator will very nearly be on the same spot. Now the day elapsed of the Julian Period (written short D. J. P.) on

| | | | |
|---|---|---|---|
| January 13, 1867, is ..... | 2402980 | 6 | 0 |
| Add ..... | 59 | 1 | 30 |
| March 13, 1867 ..... | 2403039 | 7 | 30 |

Upon referring to the column for March it will be found that on the 13th, at 7$^{h}$ 30$^{m}$ P.M., the same phase will recur; and in a similar manner it may readily be found that on May 11th, 9$^{h}$ 0$^{m}$, July 9th, 10$^{h}$ 30$^{m}$, and September 6th, 12$^{h}$ 0$^{m}$, the Terminator will be nearly in the same part of the disk, so that on those evenings the observer can resume his examination or other kind of observations under nearly similar circumstances.

*Corrections.*—When he has become familiar with his ground, the observer may proceed to examine the map and catalogue *critically*. For example, he may carefully ascertain if the *relative* position of the objects on the portion of the map furnished him be correct, and whether the alignments generally agree; for this purpose, a pair of cross wires in the field of the eye-piece, by which he can readily determine objects in the same line, will be found useful. It is important to notice particularly the outlines of objects, as should he be satisfied after observing them under differing circumstances of light and libration* that correction is needed, such correction should be made on the map either in ink or a different colour from that of the map.

*New Objects.*—As the Terminator passes over the portions of the sub-

* Libration, in a popular sense, signifies the displacement of an object as regards its mean position on the moon's surface, in which it can be observed only once in three years. When the moon has north latitude, all objects appear north of their mean places, and when she has south latitude south of them. When the moon is passing from Apogee to Perigee they are west, and when she is passing from Perigee to Apogee they are east of their mean positions.

zones selected, as well as at other times, all objects observed that are not to be found on the map nor described in the catalogue, should be inserted provisionally, their relative positions having been carefully determined by alignment or otherwise.

*Drawings.*—When opportunities occur, drawings should be made of groups, especially such as are indicated of conspicuous and easy visibility. (Difficult objects may be sketched when definition is very fine.) Reaumur, Rhæticus IV $A^{\alpha 10}$ IV $A^{\alpha 11}$ with the group near IV $A^{\zeta 1}$, also IV $A^{\zeta 25}$, IV $A^{\zeta 58}$, Halley, and Horrox are very suitable for this purpose.

*Measurements.*—The most important are for determining points of the first order, and consist of measures taken with the micrometer between the apparent east or west and north or south limbs of the moon and the object; the subject is fully treated with an example of the computation in Appendix II. Report, 1866. The mountain IV $A^{\zeta 29}$, and the craters IV $A^{\zeta 6}$, IV $A^{\zeta 7}$, and IV $A^{\zeta 12}$, appear to be very suitable as points of the first order.

Measures may also be taken for magnitude: see Report, 1865, p. 295. The following measures of Halley in a direction perpendicular to the parallel, the object being made to run between the wires, may serve as an example:—

1866, June 23, $8^h\ 10^m$ to $8^h\ 25^m$ G. M. T.

| r. | r. | | |
|---|---|---|---|
| 10·317 | 9·692 | Means .... | $\frac{10\cdot3112-9\cdot7148}{2}=\cdot2982$ |
| 10·307 | 9·717 | | |
| 10·321 | 9·727 | Dionysius | |
| 10·316 | 9·697 | 8·0 to 8·10 | $=\frac{10\cdot2366-9\cdot7732}{2}=\cdot2317.$ |
| 10·295 | 9·741 | | |

The magnitude is determined by dividing the measure of the object by that of the standard, thus: Halley=·2982, and Dionysius=·2317, therefore the magnitude of Halley $=\frac{2982}{2317}=1\cdot287.$

In reading the micrometer head, the value of the fixed wire from which the positive readings are made, is reckoned equal to ten revolutions, therefore the negative readings are equal to nine revolutions + the readings of the micrometer head, and as the difference between the two readings will equal twice the measure of the object, it follows that the mean of the positive—the mean of the negative readings—divided by 2, will equal the measure of the object.

For the reception of the observations above specified copies of Form No. 1 (Report, 1865, p. 287) will be supplied, and when corrections and additions have become sufficiently numerous, duplicate copies of the map will be furnished.

Each observation should be accompanied by references to the following data:—Greenwich mean time; day elapsed of the Julian Period (D. J. P.); the moon's latitude to the nearest minute, and the moon's nearest distance from Apogee to Perigee with the sign − before or + after. At the time of the observations given on p. 242, the moon had passed Apogee 92 hours and wanted 201 hours of Perigee. Objects were therefore west of their mean positions.

It is desirable that returns should be made at specified intervals not exceeding six lunations.

## Catalogue.

In the following Catalogue every feature seen on the photographs (as well as some of the more minute detail discoverable by the telescope) is described. The descriptions include all the points of interest that have presented themselves in the examination of this part of the moon's surface, either by the aid of photographs or by means of personal observation; and some attempt has been made to assist in obtaining a more correct representation of the moon's surface, by giving the measures in seconds of arc of the objects catalogued, and in the case of craters the deduced apparent magnitudes, the crater Dionysius being considered as the standard. These measures and deduced magnitudes can only be regarded as roughly approximate, the epochs being mean distance and mean libration; they cannot consequently be expected to coincide with any *actual* measures; for as the epoch of mean libration cannot be coincident with that of mean distance, measures made at mean distance will not agree with those made at mean libration. The basis of measurement is as follows:—the semidiameter of the moon 15′ 32″·27, as given by Oudemans from occultations and direct measurements by the heliometer (see Monthly Notices of the Royal Astronomical Society, vol. xxvi. p. 260), has been adopted, and as this gives 1864″·54 for the diameter, a scale has been adapted to the datum 100 inches=1864″·54. Rutherford's photograph, from which the measurements have been taken, is 20·875 inches in diameter, and as the measures are readily convertible from 20·875 to 100 inches, they are at once referred to mean distance, irrespective of the actual position of the moon, either as to distance or libration, and, as before stated, can only be considered as approximate; nevertheless it is hoped they may be of some service both in obtaining a better acquaintance with the moon's surface, and also contributing to its being more accurately represented.

The magnitudes *for the epoch of the photograph* have been deduced as described in my last Report (Report, 1865, p. 295), but the values are probably too small, as the measured diameter on the photograph of Dionysius appears to be excessive, the crater being surrounded by a fringe of light*. As most of the measures for magnitude have been made in a direction at right angles to a line joining the north edge of Dionysius and the south edge of Agrippa, the deduced magnitudes may be easily corrected at any future time by measurements in the same direction.

It is proper to remark that the positions have been laid down and the magnitudes in the first instance determined by a scale, radius=50 inches, all measures being expressed in parts of this scale, radius=unity. For the expression of all quantities in seconds of arc the measurements have been re-made, and directly referred to the scale, 100 inches=1864″·54, quite irrespective of the scale 50 inches=radius. The magnitudes have been determined on both scales, and the resulting mean adopted; some discrepancies, however, will be found between the measures in seconds of arc and the magnitudes, which, as before stated, are the results of two sets of measures, while the value in seconds of arc depend on one only. The greatest number of differences in this respect occur amongst those objects that range between 3″ and 4″, but as they do not materially interfere with the gradations of magnitude which range between $0^m·06$ and $0^m·70$, it is considered best to

* This fringe of light appears to vary in size, the differences in above 70 sets of measures of the diameter of Dionysius in various directions included by an angle of 50° amounting to about 6″ or 4″ more than can be accounted for by the varying distances of the moon.

give the results of the measures as they stand; especially as the object is to indicate to selenographers the work to be done, rather than to claim for the present work anything like perfection; still it is hoped that no little progress is now being made in selenography.

Wherever the word "crater" is used in the catalogue, it invariably signifies a pit, cavity, or more or less round depression, in which at sunrise or sunset a well-marked interior shadow is seen on the side next the sun, the opposite side reflecting more or less strongly the sun's rays. It is also retained with the same signification for all those objects designated craters by previous selenographers.

It has been suggested to employ the term "craterlet" for the round white glistening objects which are so numerous, particularly in the mountainous regions of the moon, associating with it the idea of a more recent formation than the larger objects. These small objects frequently occur in rows, as mentioned by Schmidt (see Appendix to last Report, 1865, pp. 305–307), and called by him crater-rills. It is in rills and crater-rills that Herr Schmidt is disposed to seek for new formations (see Report, 1865, p. 299), and recommends the particular study of them with this view. As it is important to have some distinguishing feature between ordinary craters (including even large formations) and craterlets, I would suggest for this purpose size or magnitude, all pits having a smaller diameter than mag. 0·3 or 5″ being regarded as "craterlets;" bright craters exceeding 5″ will form a class intermediate between "craterlets" and "light-centres."

In a few instances objects are mentioned as *bright* or *lucid* spots, the exact nature of which it is difficult to determine. The recent *obscuration* or probable filling up of the crater "Linné" on the Mare Serenitatis, and a *lucid spot* having been seen in its place, suggests that such objects should be carefully observed, especially when the Terminator is near them. IV $A^{\zeta 39}$, IV $A^{\zeta 71}$, and IV $A^{\zeta 102}$ may be specified as examples.

## Area IV $A^{\alpha}$.

### *Introduction.*

The positions in this area are more easterly than given by Beer and Mädler, or by Lohrmann. They are all taken in the first instance from De La Rue's photograph of the 4th of October, 1865, G. M. T. $9^h\ 0^m\ 4^s$. Libration in longitude at $11^h\ 40^m{\cdot}6 = -0°\ 39'{\cdot}7$, and latitude $= -0°\ 20'{\cdot}9$; so that the middle of the apparent disk was not very far distant from the point which is central in the orthographic projection. The libration in longitude was, however, of an extent sufficient to remove the point 0° of longitude so far to the west as to require a correction of ·020 to all measures on the photograph between 0° and 15° of latitude. On making this correction for the ordinates Y, taken from the photograph, of Messier, Theophilus, and Dollond, the south half of the central meridian exactly coincided. The central mountain of Albategnius differed from the three ordinates above-mentioned ·010. There does not appear to be any error in the mean of Lohrmann's seven measures, or in the computation as given by B. & M. of the ordinate Y of the central mountain; still in this respect the photograph differs from the computed quantity. The central mountain in Theophilus lies in nearly the same parallel as that of Albategnius, the computed difference of Y being ·36659, [illegible] measured ·37400, which also gives the position of the central mountain [illegible]bategnius more eastwardly than the computed. As the central moun-

tain of Albategnius is the only point of the first order south of the equator between 0° and 15° of south latitude and 0° and 10° west longitude, all positions in this and the neighbouring areas are measured from it either directly or indirectly on the photograph (glass) of 1858, February 22 (De La Rue), this giving the features near the middle of the disk more distinctly than that of the full moon. It is to be regretted that points of the first order are so few; the method of determining points of the second order involving a certain amount of inaccuracy, very few are found to coincide with the positions as given by measurements on the photographs. B. & M.'s points of the second order are indicated thus, ×7, &c. The crater IV $A^{\alpha 4}$ and the mountain-peak IV $A^{\zeta 29}$ on the east of Halley, may form suitable points of the first order for the areas IV $A^{\alpha}$ and IV $A^{\zeta}$. There should at least be one point of the first order in each area.

In the greater portion of this area three distinct levels may be recognized under suitable illumination; that on the south-west consists of the northern part of Hipparchus. The central level is that surrounding the crater IV $A^{\alpha 4}$, it is lower than that of Hipparchus; the surface of Reaumur constitutes the third level; it is on the east of the area.

Two great lines of disturbance from Tycho can be traced on this area, of which the western is the most prominent, and appears as a lucid ray in full moon. It presents the character of a gently swelling raised land across the smoother floor of Hipparchus in the southern part of the area, and rises into somewhat lofty cliffs on the western borders of IV $A^{\alpha 10}$, and Rhæticus in the northern. The eastern line of disturbance can be well traced to Tycho along the western borders of Ptolemæus and Alphonsus through Arzachel, having in its interior produced a ridge on which a crater is opened, it is thence continued along the west border of Thebit and east border of Purbach, and crosses IV $A^{\alpha 7}$ and IV $A^{\alpha 4}$. In areas IV $A^{\alpha}$, IV $A^{\zeta}$ a portion only of this line of disturbance appears lucid at the time of full moon.

Points of the First Order. None.

Points of the Second Order indicated thus ×.

| | X | Y | S. lat. | W. long. |
|---|---|---|---|---|
| | | | ° ′ | ° ′ |
| IV $A^{\alpha 4}$..... | ·04013 | ·05665 | 2 18 | 3 15 |
| IV $A^{\alpha 5}$..... | ·04769 | ·02440 | 2 44 | 1 24 |
| IV $A^{\alpha 6}$..... | ·07672 | ·00145 | 4 24 | 0 5 |
| IV $A^{\alpha 7}$..... | ·07527 | ·04726 | 4 19 | 2 43 |

**1. Rhæticus.—Lohrmann's map, 234, Sect. I., K. The part south of equator.

Rhæticus is a well-marked walled depression, apparently of a nearly triangular form, situated on the equator. It is one of the few formations that can have both the sun and the earth in its zenith. Its walls are perfect with the exception of two passes, one at its south angle, the other at its north-west. The west wall, which is the highest, is nearly straight, and forms part of the high land which appears in the full moon as the "Ray from Tycho" passing through the east border of Albategnius. This wall is dislocated by the fault IV $A^{\gamma 11}$, IV $A^{\beta 20}$, IV $A^{\alpha 72}$, and it is near the point of dislocation that the north-west pass is found.

The north and east walls form a somewhat semicircular mountain-range, but the north being the flattest, tends to impart to the formation a triangular

figure, and this is increased by the more gentle slope of the north interior as compared with the interior slopes of the east and west walls which are steeper. The exterior slopes, although rugged, are much more gentle than the interior. The north wall is disturbed by the same fault that has dislocated the west, the effects of which may be seen in the crater Triesnecker.

The level of the floor of this interesting formation is the lowest between IV $A^{\alpha 10}$ and the Sinus Medii. B. & M. mention and delineate a central mountain in Rhæticus. Lohrmann also gives it. I observed and sketched it 1864, April 14, and again 1867, April 11. On the west and south, and including the valley IV $A^{\alpha 58}$ on the east, Rhæticus may be said to be partly surrounded by a second wall nearly equidistant from its centre, and about the same distance from the east and west walls as the length of the east and west diameter of Rhæticus. The portion of the second wall on the west is parallel with the west wall of Rhæticus, and is also the highest.

Longest diameter from summit of north wall to the summit of south wall east of "Pass" 29″·48.

Shortest diameter at right angles to the longest, from summit of east to summit of west wall 27″·10. Riccioli's Rhæticus is situated between Stadius and Copernicus.

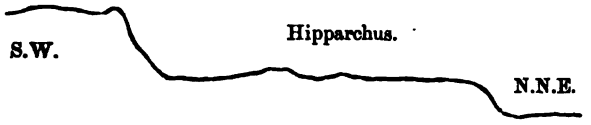
**2. Reaumur.—A somewhat depressed plain surrounded by a "wreath" of mountains, V of Lohrmann, Sect. I. 236, of his map.

Schmidt mentions a rill, No. 364, south to north across Reaumur. I do not find it on the photograph. It was discovered in 1853, May 14, with the Berlin refractor.

3. Hipparchus.—Lohrmann's map, 233. The north-east part.

This formation, which is very strongly individualized by Lohrmann in his Section I. (*Topographie der Sichtbaren Mondoberfläche*), and nearly as much so by B. & M., can hardly be said to possess so distinct a character, for it is only when the terminator is in its neighbourhood that its real features are well seen. Indeed, B. & M. describe it as an assemblage of diverse lunar forms, rather than a general whole, which are only seen to advantage near the time of sunrise and sunset; for at these times, especially at sunrise, the interior surface, of a dark-grey and furrowed through by long shadows, separates itself distinctly from the brighter environs. According to later observations, it appears to consist of a tract of land between two depressions, Albategnius, and the low land IV $A^{\alpha 11}$, which surrounds the crater IV $A^{\alpha 4}$. Of these depressions Albategnius is the lowest. The surface of Hipparchus is slightly convex, the highest point being near the formation IV $A^{\zeta 58}$. Its boundaries differ very considerably from the ordinary boundaries of walled plains, so much so that it can scarcely be regarded as a formation of this class. As figured by Lohrmann and B. & M., its S.W. boundary commences near the bright crater IV $A^{\zeta 33}$, and is continued in a nearly straight line to the valley IV $A^{\eta 6}$. This boundary is really that of the mass of high land in which Halley, Hind, IV $A^{\eta 2}$ and IV $A^{\eta 8}$, are opened, and which appears to be the highest in this part of the moon; and the boundary is continued as a high steep range of mountains E.S.E. along the steep crater rill IV $A^{\zeta 67}$ on the north of Albategnius to the junction of the S.W. and west borders of Ptolemæus and Alphonsus. The west border of Hipparchus coincides with the "fault" IV $A^{\eta 11}$, IV $A^{\beta 20}$, IV $A^{\alpha 72}$ (this fault extends as far as or beyond necker). The north boundary differs in a very marked degree from the , inasmuch as the land on the S.W. rises to a considerable elevation,

while on the N.N.E. it is depressed. The north boundary consists of cliffs which do not appear to rise much, if at all, above the surface of Hipparchus,




their faces looking towards the depressed land IV $A^{\alpha 11}$. It is this feature which occasions the evanescent character of Hipparchus, so that in about *forty*-eight hours after the terminator has passed it, this boundary is no longer discernible. It is in the neighbourhood of IV $A^{\alpha 7}$ that the cliffs begin to rise to any extent above the surface of Hipparchus, and it is here that the east boundary commences. This boundary passes through IV $A^{\alpha 17}$, IV $A^{\zeta 39}$, the mountains IV $A^{\zeta 37}$ and IV $A^{\zeta 61}$, the west slope of IV $A^{\zeta 6}$ to IV $A^{\zeta 33}$, where the S.W. boundary commences.

The south angle of Hipparchus is filled with the formation IV $A^{\zeta 25}$, which is slightly depressed below its level, the land filling the angle between Albategnius and Ptolemæus being higher.

*4. A crater just S.W. of a line joining the south point of Rhæticus with the S.W. point of Reaumur. H. of B. & M. 6″·18, mag. 0·37. Shown by Lohrmann.

This crater, although neither large nor bright, is yet sufficiently conspicuous to form a point of the "First Order." Its position, second order, × 4, as given by B. & M., is ·0145 west of its position as measured on the photographs.

This crater is very interestingly situated on the depressed land IV $A^{\alpha 11}$, extending between Rhæticus, Horrox, and Reaumur, and is surrounded by mountains and cliffs disposed in a nearly circular form at an average distance of 24″·73. These mountains, however, must not be regarded as by any means *intimately* connected with the crater; for the ranges of which they form parts have over a very extensive area a general direction S.S.W.–N.N.E.; but the interesting feature is, that with the exception of those to the N.E., the summits of the mountains in the neighbourhood of IV $A^{\alpha 4}$ attain their greatest altitudes at or about the distance above named. We are not without *numerous* instances of craters being accompanied by strong evidences of their having been centres of considerable disturbance; and although but few radiating marks are found characterizing IV $A^{\alpha 4}$, yet they are not entirely wanting, as doubtless large apertures will show; so that it is not unlikely that while the general mountain formations originated by the operation of a force of a very extensive character, the outburst which produced IV $A^{\alpha 4}$ might within its range of action have modified the surrounding surface. It is noteworthy that IV $A^{\alpha 4}$ and the group IV $A^{\alpha 7}$ are opened upon a "Ray from Tycho," which is coincident with the high ranges forming the west borders of Ptolemæus and Alphonsus, and also with the crater and ridge on Arzachel. It is probable some of the highest peaks in the central portion of the southern hemisphere may be found on this ray. Its direction is S.S.E.–N.N.W., and, as mentioned under IV $A^{\zeta}$, is to be referred to a more recent convulsion than that which produced the lines of disturbance having a general direction S.S.W.–N.N.E.

5. A mountain-peak on the S.W. border of Reaumur, A of B. & M.

Length of crest 8″·08. Position, second order, ×5, ·0103 west of photograph. Not well shown by Lohrmann.

This peak is a conspicuous object on the line of cliffs extending from the east of Ptolemæus past Herschel (III $A^{\zeta 1}$), and the west rim of Reaumur to the S.W. end of the rill of Hyginus. See partial description in Notes on III $A^{\zeta}$.

*6. A crater S.E. of Reaumur 8″·08, mag. 0·5.

In consequence of the position of objects being more to the east in area IV $A^{\alpha}$, the west border only comes into IV $A^{\alpha}$. The crater is a conspicuous object on the line of cliffs noticed under IV $A^{\alpha 5}$. 92 Lohrmann, Sec. I.

*7. A crater between Reaumur and Halley, also between Herschel and Horrox. F of B. & M., 5″·71, mag. 0·34. Position second order ×7, ·0139 west of photograph.

This crater is placed by B. & M. and Lohrmann on the N.E. border of Hipparchus, which is figured both by B. & M. and Lohrmann, as a plain surrounded by mountains (see *ante*, p. 248), 1867, Feb. 11, I found it, as figured by B. & M. and Lohrmann, opened on a mountain. It is probable that a mountainous connexion exists between Reaumur and IV $A^{\zeta 86}$.

8. The N.W. part of the line of cliffs from Reaumur to Herschel.

*9. The N.W. part of a plain west of Herschel, the W of Lohrmann, Sect. I. See IV $A^{\zeta 24}$.

**10. A crater-form depression south of Rhæticus.

This depression, which is a very conspicuous and well-marked object on the photograph of February 22, 1858, is hardly if at all recognizable on B. & M.'s map or Lohrmann's, Sect. I. Its form is sufficiently remarkable to arrest the attention. The southern part presents the appearance of a crater which is elongated, and contracted towards the north, from whence a valley IV $A^{\alpha 35}$ extends towards Rhæticus.

The south end of IV $A^{\alpha 10}$ forms a somewhat high cliff, IV $A^{\alpha 14}$, as compared with its interior. The valley IV $A^{\alpha 32}$ is excavated in this cliff; IV $A^{\alpha 10}$ is more particularly described under IV $A^{\alpha 42}$.

The west border of Rhæticus, and also that of IV $A^{\alpha 10}$, the cliffs passing east of Horrox and crossing Hipparchus with the formation IV $A^{\zeta 25}$, and the mountains continued as far as the crater IV $A^{\lambda 6}$ on the east of Albategnius, together form a line of cliffs with gently sloping faces towards the west by south. This line of cliffs comes out in the full moon as a "Ray" directed towards Tycho. It is well marked, and more or less continuous, although in many places it suffers interruptions.

11. The tract of low land surrounding IV $A^{\alpha 4}$ discovered by W. R. Birt, 1866, Nov. 14.

It is principally at the time of sunrise that this tract is perceptible as a depressed surface; at other times, except that of sunset, it is scarcely if at all distinguishable from the surface of Hipparchus.

12. A somewhat wide valley between IV $A^{\alpha 32}$ and IV $A^{\alpha 30}$ on the line of cliffs from IV $A^{\alpha 7}$ to IV $A^{\alpha 10}$. The east and west sides rise into eminences; IV $A^{\alpha 30}$ on the east is immediately between IV $A^{\alpha 12}$ and IV $A^{\alpha 13}$, its sloping sides forming respectively the east and west interiors of the depressions adjoining. An attentive inspection will, however, convince the observer that IV $A^{\alpha 30}$ is a mountain sloping

in *every* direction, and that the depressions east and west present the characteristics of valleys in the line of cliffs on the south border of IV $A^{\alpha 11}$. The eminence on the west is the east side of the valley IV $A^{\alpha 32}$. The approximate measures of IV $A^{\alpha 12}$ are, length S.S.W.–N.N.E., 12″·0, breadth 9″·0.

13. A bay in the south border of IV $A^{\alpha 11}$ between IV $A^{\alpha 12}$ and IV $A^{\alpha 28}$.

14. A cliff or mountain-peak south of IV $A^{\alpha 10}$. Shown by Lohrmann. From this cliff there are three divergent lines, one slightly west of south to IV $A^{\zeta 58}$; this (IV $A^{\alpha 49}$) forms the west foot of the cliff, IV $A^{\zeta 38}$, IV $A^{\alpha 33}$, IV $A^{\alpha 14}$; one nearly due south, but slightly inclined to east, this forms the summit of the cliff IV $A^{\zeta 38}$, which is furrowed by IV $A^{\zeta 81}$. The third passes through the mountain IV $A^{\zeta 37}$, and in the south part of its course is coincident with the east edge of the *shallow* and *sinuous* continuation of the valley IV $A^{\zeta 85}$.

IV $A^{\alpha 14}$, IV $A^{\alpha 32}$, IV $A^{\alpha 12}$, IV $A^{\alpha 30}$, IV $A^{\alpha 13}$, and IV $A^{\alpha 28}$ exhibit a well-marked and characteristic line of cliffs south of the crater IV $A^{\alpha 4}$; a depression IV $A^{\alpha 20}$, not unlike IV $A^{\alpha 12}$ and IV $A^{\alpha 13}$, connects IV $A^{\alpha 4}$ with this line, to which, with the mountains around, IV $A^{\alpha 4}$, stands somewhat in the relation of a centre.

15. A short mountain-range extending S.E. from the S.E. border of Rhæticus. IV $A^{\alpha 7}$ and IV $A^{\zeta 49}$ with III $A^{\zeta 16}$, the crater on the floor of Ptolemæus, are in the continuation of this line.

16. A mountain-peak on the west border of Reaumur. Length of crest 7″·13; probably B. & M.'s $\beta$. Not well shown by Lohrmann.

17. A bright spot S.S.W. of IV $A^{\alpha 7}$, the north part. 5″·94, mag. 0·37; probably a crater in the east boundary of Hipparchus. See IV $A^{\zeta 39}$.

*18. A craterlet S.E. of Horrox. 2″·85, mag. 0·18.

19. A mountain-peak on the N.W. border of Reaumur. Length 7″·13. IV $A^{\alpha 16}$ and IV $A^{\alpha 19}$ are in continuation with a slight break. IV $A^{\alpha 5}$ and IV $A^{\alpha 16}$ are quite detached. None are shown well by Lohrmann.

20. A depression between IV $A^{\alpha 4}$ and IV $A^{\alpha 13}$, and also IV $A^{\alpha 28}$. Direction S.S.W., length 12″·36, breadth 6″·66. Two rays proceed from the E.S.E. side; the S.S.W. ray extends as far as IV $A^{\alpha 27}$, and the N.N.E. ray nearly as far as IV $A^{\alpha 21}$. The depression consists of two parts, one to the S.S.W., the other to the N.N.E., not very unlike *two* craters that had coalesced. This, however, is hardly likely to have been the nature of their origin, for they rather appear to be *hollows* in the E.S.E. side of the chain of low mountains or cliffs running towards Hipparchus. Two summits in this chain are discernible, IV $A^{\alpha 30}$ at the W.N.W. end of the depression, IV $A^{\alpha 13}$ and IV $A^{\alpha 31}$ forming the S.W. part of IV $A^{\alpha 20}$. A somewhat similar formation, IV $A^{\zeta 54}$, but rather smaller, occurs near and to the south of the group IV $A^{\zeta 1}$; both IV $A^{\alpha 20}$ and IV $A^{\zeta 54}$ have the same direction.

21. A mountain S.W. of IV $A^{\alpha 5}$ with a spur running between IV $A^{\alpha 25}$ and IV $A^{\alpha 27}$. Ill figured by Lohrmann.

22. A craterlet E.S.E. of IV $A^{\alpha 7}$ 8″·6, mag. 0·21. Not in Lohrmann.

23. A craterlet S.E. of IV $A^{\alpha 22}$ 2″·85, mag. 0·18.

IV $A^{\alpha 7}$, IV $A^{\alpha 22}$, and IV $A^{\alpha 23}$ form a short crater-row; length 12″·4, which with IV $A^{\alpha 24}$, IV $A^{\alpha 26}$, and the mountains extending towards Rümker, form an interesting group between IV $A^{\zeta 1}$ and its surroundings, and IV $A^{\alpha 4}$. It is, however, not nearly so conspicuous as the group IV $A^{\zeta 1}$.

24. A somewhat shallow crater opening into the valley IV $A^{\alpha 29}$. It lies in the line of disturbance IV $A^{\alpha 5}$—IV $A^{\alpha 7}$. 6″·66, mag. 0·39.

This line is *very exactly* in the prolongation of VIII. S.S.W. of IV $A^{\zeta}$, but separated from it by the comparatively smooth floor of Hipparchus, which extends here over a wide space.

25. A short mountain-range east of IV $A^{\alpha 24}$ and IV $A^{\alpha 21}$; length of crest 11″·0. It appears to take its rise at the east edge of IV $A^{\alpha 24}$, and nearly fills the angle of IV $A^{\alpha 21}$.

26. A craterlet W.N.W. of IV $A^{\alpha 24}$, 3″·1, mag. 0·18, shown by B. & M. but misplaced. Shown much larger by Lohrmann?

27. A short mountain-range, crest somewhat sinuous, extending from IV $A^{\alpha 24}$ and IV $A^{\alpha 26}$ towards IV $A^{\alpha 16}$; length of crest 11″·4.

28. A short mountain-range west of IV $A^{\alpha 7}$ and IV $A^{\alpha 26}$, directed S.S.W., length of crest 8″·56, breadth of base 6″·18. The W.N.W. slope appears to be more gentle than the opposite, and the crest is rounded. The north end of this mountain-range appears to be B. & M.'s γ, and Lohrmann's Sec. I. 33.

29. The valley between IV $A^{\alpha 25}$ and IV $A^{\alpha 27}$, apparently communicating with IV $A^{\alpha 24}$. Shown by Lohrmann.

30. A mountain between the depressions IV $A^{\alpha 12}$ and IV $A^{\alpha 13}$.

31. A mountain at the S.W. end of IV $A^{\alpha 20}$; its west slope is prominent. Shown by Lohrmann, Sec. I. near 32 and 33.

32. A short valley S.S.E. of IV $A^{\alpha 10}$, length 14″·74, breadth 5″·23.

This valley is *very exactly* in the line of the similar valley IV $A^{\eta 18}$ which pierces the line of cliffs IV $A^{\eta 16}$, forming the south-west border of Hipparchus. The surface of Hipparchus from IV $A^{\eta 18}$ to the cliff IV $A^{\alpha 14}$, on which IV $A^{\alpha 32}$ is situated, appears to be smooth. The direction of the line joining the valleys (S.S.W.) is sensibly parallel with the lines VIII. S.S.W., IX. S.S.W. Area IV $A^{\zeta}$. The S.S.W. mouth of IV $A^{\alpha 32}$ is blocked by the summit of the cliff IV $A^{\alpha 33}$ coincident with the "Ray from Tycho."

33. The northern part of the cliff IV $A^{\zeta 38}$.

The cliff, or rather the gently rising or swelling ground of which IV $A^{\zeta 34}$ is the southern extremity, extends lengthwise from the north of IV $A^{\zeta 25}$, where it is broadest, to the west of IV $A^{\alpha 10}$, where it merges into the cliff IV $A^{\alpha 14}$. The west foot is well marked as it crosses Hipparchus.

34. The east part of the interior slope of Horrox, IV $A^{\beta 16}$.

35. A small hillock on the east of Horrox, 2″·38, mag. 0·16.

IV $A^{\zeta 100}$, IV $A^{\alpha 18}$, and IV $A^{\alpha 35}$ are upon the foot of the rising ground IV $A^{\zeta 38}$, IV $A^{\alpha 33}$. A faint ray connects IV $A^{\alpha 35}$ with the mountain at the extremity of IV $A^{\alpha 32}$ in the direction of the dotted line.

36. A short mountain-range nearly crossing IV A$^{\alpha}$ 10, length of crest 12″·36. Not well shown by Lohrmann.

This mountain-range lies *precisely* in the direction of a faint ray, IV A$^{\alpha}$ 83, n IV A$^{\alpha}$ 4.

37. Two adjoining mountains on the west border of IV A$^{\alpha}$ 10.

38. An elongated depression or valley in the north part of IV A$^{\alpha}$ 10 (see IV A$^{\alpha}$ 42). Not in Lohrmann.

39. A mountain on the west border of IV A$^{\alpha}$ 38.

40. A mountain-range, its south end projecting into IV A$^{\alpha}$ 38.

41. A lucid spot west of IV A$^{\alpha}$ 4, probably the south slope of an eminence on IV A$^{\alpha}$ 15. Not in Lohrmann.

42. A line of fault extending north from IV A$^{\alpha}$ 12 which it crosses. It is continued east of IV A$^{\alpha}$ 10 as far as the range IV A$^{\alpha}$ 15, and reappears on the north side of IV A$^{\alpha}$ 15 in the ridge IV A$^{\alpha}$ 43.

The surface immediately west of this fault is very greatly disturbed, exhiting a series of somewhat intricate formations, which are ill figured both y B. & M. and Lohrmann. The most remarkable are IV A$^{\alpha}$ 10, IV A$^{\alpha}$ 38, nd IV A$^{\alpha}$ 40. As these formations appear to be intimately connected, it may perhaps be better to describe them with the fault. IV A$^{\alpha}$ 10 is a considerable depression, a little east of the line joining Rhæticus and Horrox. Its west side, which is continued in a N.N.E. direction, as the west side of IV A$^{\alpha}$ 38 s rather considerably elevated. It is on the "Ray from Tycho," and is marked by the peaks IV A$^{\alpha}$ 14 at its south end, IV A$^{\alpha}$ 37 (two) on its west ide, and IV A$^{\alpha}$ 39 at its junction with IV A$^{\alpha}$ 38, and also the cliff IV A$^{\alpha}$ 50. An interior ledge on the west side is visible. The floor of IV A$^{\alpha}$ 10 is irregular and rough, the east interior slope being seen under a suitable illumination rising from it. The most interesting feature of IV A$^{\alpha}$ 10 is a ridge, IV A$^{\alpha}$ 36, nearly but not quite crossing it from east to west. A faint ray, IV A$^{\alpha}$ 83, extends between the east end of this ridge and the crater IV A$^{\alpha}$ 4, and is continued (IV A$^{\alpha}$ 61) in a slightly altered direction on the opposite side of IV A$^{\alpha}$ 4. The north part of the depression IV A$^{\alpha}$ 10 is connected with the south, round the west extremity of IV A$^{\alpha}$ 36. South of IV A$^{\alpha}$ 10 is the valley IV A$^{\alpha}$ 32; the two, however, are not connected, although there is a partial depression in the south wall of IV A$^{\alpha}$ 10, for IV A$^{\alpha}$ 10 is much deeper than IV A$^{\alpha}$ 32.

Running into IV A$^{\alpha}$ 10 on the north, is the depression IV A$^{\alpha}$ 38, *closed* at its south end; both the east and west sides are somewhat elevated, but the north is entirely open, giving ingress to the narrow extremity of the mountain-range IV A$^{\alpha}$ 40. All the depressions to the south of Rhæticus are very unlike "craters," as a single glance at Horrox will sufficiently indicate. They appear to fill the space between two ranges of mountains which diverge from a point south-east of Rhæticus. This space attains its greatest width in the neighbourhood of the mountain-range IV A$^{\alpha}$ 36, which nearly crosses IV A$^{\alpha}$ 10, and the two ranges unite at the south-west extremity of the valley IV A$^{\alpha}$ 32. The axis of the larger irregular and partially blocked valley, extending from

Rhæticus to the S.W. end of IV A$^{\alpha 32}$, is parallel with the line of fault IV A$^{\alpha 42}$.

The surface on the east of the south part of the line of fault is very different. Between it and the mountains IV A$^{\alpha 30}$ and IV A$^{\alpha 31}$, it appears to be generally smooth, but diversified by rays which in a measure, although not very marked, converge to IV A$^{\alpha 4}$ as a centre. Between IV A$^{\alpha 4}$ and IV A$^{\alpha 38}$ is the lucid spot IV A$^{\alpha 41}$.

43. A mountain-ridge in the continuation of the line of fault IV A$^{\alpha 42}$, direction S. by W., face toward W. by N., length 23″·0. It has upon it three craterlets.
44. The south of two craterlets near the south end of IV A$^{\alpha 43}$ 1″·0, mag. 0·06. Not in Lohrmann.
45. The north of two craterlets near the south end of IV A$^{\alpha 43}$ 1″·0, mag. 0·06. Not in Lohrmann.
46. A craterlet on the north part of IV A$^{\alpha 43}$ 1″·0, mag. 0·06.
47. A deep cleft on the south border of the Sinus Medii.

The east side of this cleft is a continuation of IV A$^{\alpha 43}$.

48. The south part of the second wall of Rhæticus.
49. A line of fault extending from the south part of IV A$^{\zeta 58}$ to the west border of Rhæticus, where it intersects the fault IV A$^{\alpha 11}$, IV A$^{\beta 20}$, IV A$^{\alpha 72}$. The portion between IV A$^{\alpha 10}$ and IV A$^{\alpha 1}$ (Rhæticus) is on the "Ray from Tycho."
50. A cliff on the north part of the west border of IV A$^{\alpha 38}$.
**51. The mountain-arm west of IV A$^{\alpha 9}$, IV A$^{\zeta 24}$, the north part.
52. A curved mountain-range extending from IV A$^{\alpha 22}$ to the east part of the valley IV A$^{\alpha 29}$.
53. A short shallow valley on the north border of IV A$^{\alpha 9}$, length 8″·58, breadth 9″·99. Lohrmann's Sec. I. 90.
54. A chain of mountains extending from the west border of IV A$^{\alpha 6}$ to the south of Reaumur, length 13″·0. Shown by Lohrmann.
55. A mountain between IV A$^{\alpha 51}$ and Reaumur, also between IV A$^{\alpha 79}$ and IV A$^{\alpha 80}$.
56. A mountain N.W. of IV A$^{\alpha 55}$. 3″·5.
57. A craterlet on the south border of Reaumur. 3″·8, mag. 0·26.
58. A valley east of and parallel with IV A$^{\alpha 43}$.

This valley is very interestingly situated with regard to Rhæticus. It is about as far from the east border of Rhæticus as the west portion of the second wall is from the west border, but unlike this portion, in its being depressed, instead of elevated above the surface. The directions of the two are also different, the high west ranges being S.S.E., and the depressed valley south by west. Their directions produced meet at the south part of IV A$^{\zeta 58}$, but there are no indications of any connecting formations. The space between Rhæticus and IV A$^{\alpha 58}$ is occupied by rugged ground, about the middle of which the ridge IV A$^{\alpha 43}$ is elevated.

IV A$^{\alpha 58}$ lies *very exactly* in the line of depression IV A$^{\alpha 17}$, IV A$^{\alpha 24}$, IV A$^{\alpha 12}$, the direction of which is south by west. This line of depression intersects VIII. S.S.W. in the mountain IV A$^{\zeta 29}$.

59. A ridge between IV $A^{\alpha 47}$ and the north end of IV $A^{\alpha 58}$. This ridge is on the line of cliffs between Ptolemæus and the S.W. end of the rill of Hyginus.

60. A craterlet north by east of IV $A^{\alpha 58}$. 3″·5, mag. 0·21.

61. A ray from IV $A^{\alpha 4}$, extending in a N.E. direction as far as the range of cliffs N.W. of Reaumur. Schmidt's rill, No. 365, N.W.–S.E., discovered by him in 1853, May 14, with the Berlin refractor, is near this ray. I do not find the rill on the photographs.

62. A low ridge from IV $A^{\alpha 16}$ to IV $A^{\alpha 58}$, forming a depressed portion of the line of cliffs from Ptolemæus to the S.W. end of the rill of Hyginus.

63. A mountain on IV $A^{\alpha 62}$. Probably shown by Lohrmann.

64. A curved mountain-range between IV $A^{\alpha 19}$ and IV $A^{\alpha 61}$.

65. A curved mountain-range N.W. of IV $A^{\alpha 61}$.

66. A low ridge connecting IV $A^{\alpha 61}$ with IV $A^{\alpha 65}$.

This low ridge is nearly parallel with the depressed portion between IV $A^{\alpha 16}$ and IV $A^{\alpha 58}$ of the line of cliffs from Ptolemæus to the rill of Hyginus.

67. The S.W. border of Reaumur.

68. A dark spot east of IV $A^{\alpha 65}$.

69. A dark spot north of Reaumur.

70. A light spot north of IV $A^{\alpha 68}$.

IV $A^{\alpha 68}$, IV $A^{\alpha 69}$, and IV $A^{\alpha 70}$ form part of a line of cliffs north and N.W. of Reaumur. It is shown by Lohrmann.

71. A bright spot between IV $A^{\beta 16}$ (Horrox) and IV $A^{\alpha 17}$.

72. Part of the "Fault" IV $A^{\eta 11}$, IV $A^{\beta 20}$.

This interesting "Fault," which is of considerable extent, takes its rise in the crater IV $A^{\eta 2}$, the north border of which is cracked by it. The fault has dislocated the S.E. end of the mountain-chain IV $A^{\eta 12}$, and produced the long narrow valley IV $A^{\eta 11}$. About the middle of IV $A^{\eta 11}$ it is intersected by the fault IV $A^{\eta 23}$, which taking its rise on the east border of Hind, can be traced nearly as far as Godin. This fault, IV $A^{\eta 23}$, is coincident with the "Ray from Tycho" which passes through or along the west border of Albategnius, and also crosses the Mare Serenitatis. It is on this Ray that Bessel is situated. Just north of the point of intersection of the two faults the ground rises, the crater IV $A^{\beta 19}$ being included in the angle formed by the intersection. Near the point of intersection the fault IV $A^{\eta 11}$ enters the area IV $A^{\beta}$, in which it is designated as IV $A^{\beta 20}$. On the extreme edges of the cliffs formed by IV $A^{\beta 20}$, the small craters IV $A^{\beta 21}$ and IV $A^{\beta 15}$ have been opened. From IV $A^{\beta 15}$ the fault proceeds directly to the west border of Rhæticus, having dislocated IV $A^{\beta 33}$, the west portion of IV $A^{\alpha 48}$. The west and north borders of Rhæticus have suffered very marked dislocations by this fault. Its effects are *not* visible on the smooth surface south of Triesnecker, which—as well as the crater Ukert—has suffered by it, and much disturbance occurs in the same line as far as the Apennines.

An interesting question as to priority of epoch suggests itself in connexion with these faults. The neighbourhood of IV $A^{\zeta 36}$ indicates that of the two

lines intersecting at that point, the one from Tycho is the most recent. Now the ray from Tycho, on which the fault IV $A^{\eta\,23}$ occurs, is nearly parallel with the one on which IV $A^{\zeta\,36}$ is found, and it may be of nearly the same age. The fault IV $A^{\eta\,11}$, IV $A^{\beta\,20}$, IV $A^{\alpha\,72}$, which intersects IV $A^{\eta\,23}$, is nowhere *obliterated* between IV $A^{\eta\,2}$ and the north border of Rhæticus, while in the neighbourhood of IV $A^{\beta\,19}$ the fault IV $A^{\eta\,25}$ *is obliterated*, the elevated ground on which the crater is situated effacing it. Does this point to a more recent epoch than that of Tycho for the outburst of the crater IV $A^{\eta\,2}$? Also, Is the fault IV $A^{\eta\,23}$ more recent than the ray from Tycho on which it occurs?

73. A rill from IV $A^{\alpha\,28}$ to IV $A^{\alpha\,16}$, length 21″·87. Schmidt, No. 363.

Schmidt discovered this rill in 1853, on May 14, with the Berlin refractor. He describes it as having a N.E. and S.W. direction, and extending from Hipparchus $\gamma$ to Reaumur $\beta$ of B. & M.'s map. It is very faintly traceable on the photograph, and may probably be a crater-rill.

74. A rill crossing Rhæticus from S.E. to N.W. Schmidt, No. 366.

This rill was also discovered by Schmidt in 1853, on May 14, with the Berlin refractor. There is another rill more to the N. in Quadrant I. crossing Rhæticus, probably Nos. 47 and 48 of Schmidt's Catalogue. These were discovered by him on the same day, and with the same instrument with which he discovered the above-mentioned rills, viz. Nos. 363, 364, 365, and 366. Both the rills in Rhæticus are apparent on the photograph.

‡75. The continuation of the shallow part of the valley IV $A^{\zeta\,85}$.

‡76. The depressed portion of the valley IV $A^{\alpha\,75}$ discovered by W. R. Birt, 1866, Nov. 14, with the Royal Society's achromatic of $4\frac{1}{4}$-inch aperture, power 230.

This object, as well as the valley of which it forms part, is very evanescent, being visible only about the time of sunrise.

77. A valley-like depression running S.W.–N.E. between the faults IV $A^{\beta\,20}$ and IV $A^{\alpha\,49}$, from IV $A^{\beta\,30}$ to IV $A^{\alpha\,78}$.

78. A crater in the angle between IV $A^{\alpha\,38}$ and IV $A^{\alpha\,48}$, length E.–W. 9″·03, breadth S.–N. 4″·76, mag. 0·42.

79. A depression on the S.W. slope of IV $A^{\alpha\,54}$, most probably *b* of B. & M., length 4″·76.

80. A mountain-range running between IV $A^{\alpha\,23}$ and IV $A^{\alpha\,55}$, length of crest 22″·82. Probably the S.E. side of Lohrmann's 87, Sec. I.

81. A depression on the S.W. slope of IV $A^{\alpha\,54}$, N.N.W. of IV $A^{\alpha\,79}$, length 6″·66.

82. A small depression north of IV $A^{\alpha\,13}$. 2″·3, mag. 0·15.

83. The ray from IV $A^{\alpha\,4}$ to IV $A^{\alpha\,36}$.

84. A mountain-peak on the N.W. border of Reaumur in continuation of IV $A^{\alpha\,19}$, length 6″·18. IV $A^{\alpha\,16}$, IV $A^{\alpha\,19}$, and IV $A^{\alpha\,84}$ form an almost continuous mountain-chain on the N.W. border of Reaumur, length 22″·35. This mountain-chain is connected with IV $A^{\alpha\,28}$ by the rill IV $A^{\alpha\,73}$.

85. A shallow depression west of IV $A^{\alpha\,70}$. 3′·33.

## Area IV $A^{\zeta}$.

*Introduction.*

The greater portion of this area, which possesses much irregularity of surface, is principally occupied by four groups of objects, viz., those on the rocky land—partly surrounding a plain—in the angle formed by the N.E. border of Albategnius and the N.W. border of Ptolemæus; the crater group in the north angle of Albategnius; the slightly depressed surface IV $A^{\zeta 25}$; and the lower land north of the crater-row from IV $A^{\zeta 1}$ to Ptolemæus. These groups occupy nearly twenty superficial degrees, or about 6953 square miles. The remainder of the area, about 1857 square miles, is occupied with the much more level surface of the south part of Hipparchus and the region east of it.

In the four groups of lunar objects above named there are no large craters; the largest is IV $A^{\zeta 1}$, which measures 10″·94, mag. 0·70. The following arrangement shows the distribution of 44 as to size:—

| Between | 1″—2″ | 2″—3″ | 3″—4″ | 4″—5″ | 5″—6″ | 6″—7″ | 7″—8″ |
|---|---|---|---|---|---|---|---|
| Objects.. | 3 | 10 | 11 | 6 | 6 | 4 | 4 |

Points of the First Order. None.

Points of the Second Order indicated thus ×.

| | X | Y | S. lat. | W. long. |
|---|---|---|---|---|
| | | | ° ′ | ° ′ |
| IV $A^{\zeta 7}$.... | ·13716 | ·03486 | 7 53 | 2 1 |
| IV $A^{\zeta 10}$... | ·17250 | ·08157 | 9 56 | 4 45 |
| IV $A^{\zeta 12}$... | ·16476 | ·03012 | 9 29 | 1 45 |

**1. A crater situated on the rocky land between Ptolemæus and Hipparchus. Lohrmann, 235 on map, X in Section I., who describes it as of 16·1 English miles in diameter, 7° of brightness, the floor being 5°, mag. 0·70. I suspect a central mountain in it.

This crater is of irregular form and not *round*, as given by Lohrmann. A line between IV $A^{\zeta 5}$ and IV $A^{\zeta 7}$ measures 10″·94. The figure is that of a very irregular trapezium; the sides, however, are not right lines, but more or less curved. The longest side, 12″·36, which is sensibly curved, is from south-east to north-west, the exterior slope facing the north-east. It includes the promontory on the border towards IV $A^{\zeta 13}$. The next longest side, 9″·03, is from south-west to north-east, the exterior slope facing the north-west. The two remaining sides do not much differ from this in length. At the south end of the crater, and between the south-east and south-west walls, is a break or "pass," IV $A^{\zeta 2}$, not unlike the "gorge" at the north-west point of Rhæticus. [*Qy.* Is this "pass" at the south-west end of Webb's Furrow, between the craters IV $A^{\zeta 4}$ and IV $A^{\zeta 5}$?] It is not shown by Lohrmann, but can be traced in the position queried on De La Rue's and Rutherford's photographs. Just exterior to the south-west wall are the two craters, IV $A^{\zeta 4}$ and IV $A^{\zeta 5}$. Exterior to the south-east wall, and lying close to it, are two dimples, IV $A^{\zeta 8}$ and IV $A^{\zeta 9}$, not in any way indicated by Lohrmann nor by B. & M. From these a row of five craterlets extend to the west border of Ptolemæus. B. & M. give and mention six; probably they may include the dimples, as there is some doubt about IV $A^{\zeta 19}$, the craterlet nearest the wall of Ptolemæus, being really one, the rising ground tending to

produce such an appearance. Mr. Ingall has observed an excavation in the mountain-slope.

At the north point of IV $A^{\zeta 1}$ is a crater, IV $A^{\zeta 7}$, probably a little larger than either IV $A^{\zeta 4}$ or IV $A^{\zeta 5}$, and this has a minute craterlet on the east, and also one on the west.

The crater IV $A^{\zeta 1}$ has a "furrow" crossing the interior of the south-east wall, in the direction of the crater-row IV $A^{\zeta 13}$–IV $A^{\zeta 19}$ (see IV $A^{\zeta 20}$). It is worthy of remark that a prolongation of this crater-row and furrow will pass through the bright mountain IV $A^{\zeta 32}$.

†2. A pass or "gully" in the south end of IV $A^{\zeta 1}$. Recorded in Obs. Bk. 1864, Sept. $22^d$ $15^h$ $45^m$ G. M. T. No. 292, p. 102, Roy. Soc. $4\frac{1}{4}$, power 230. Definition "very good."

*3. A depression or crater on the N.W. border of Ptolemæus. Length S.S.W. to N.N.E. 9″·03, breadth W.N.W. to E.S.E. 4″·76.

**4. The N.W. of two craters S.W. of IV $A^{\zeta 1}$ 5″·23, mag. 0·33.

**5. The S.E. of two craters S.W. of IV $A^{\zeta 1}$ 4″·76, mag. 0·32.

Lohrmann gives both these craters, and mentions them in his text (Topographie der Sichtbaren Mondoberfläche, erste Abtheilung, p. 55, Sec. I. XI. Beer and Mädler give only one.

**6. A crater on the S.E. border of Hipparchus 6″·66, mag. 0·44. i of B. & M. 35. Sec. I. of Lohrmann.

**7. A crater just north of IV $A^{\zeta 1}$ 6″·18, mag. 0·40 (Beer and Mädler's position of the second order K is indicated by 7 × on IV $A^{\zeta 4}$).

IV $A^{\zeta 1}$, IV $A^{\zeta 4}$, IV $A^{\zeta 5}$, IV $A^{\zeta 6}$, and IV $A^{\zeta 7}$ form a very interesting and conspicuous group, the conformation of 1, 4, 5, and 7 contributing to its being easily found at some distance from the "terminator."

‡8. The S.W. of two small dimples just S.E. of IV $A^{\zeta 1}$, estimated 3″·5, mag. 0·21.

‡9. The N.E. of two small dimples just S.E. of IV $A^{\zeta 1}$, estimated 3″·5, mag. 0·21.

IV $A^{\zeta 8}$ and IV $A^{\zeta 9}$ are both recorded in Obs. Bk. 1864, Sept. $22^d$ $16^h$ $0^m$ G. M. T., No. 292, p. 103, Roy. Soc. $4\frac{1}{4}$, power 230. Definition admirable; they are difficult objects.

*10. A crater on the interior N.W. border of Albategnius 6″·18, mag. 0·37. Position of second order × 10 on its S.E. margin.

11. Hipparchus.—Lohrmann's map 233, the S.E. part.

The S.W. part is shown in area IV $A^{\eta}$. The floor of Hipparchus is *convex*, the highest part being in the neighbourhood of IV $A^{\zeta 58}$, probably the cliff IV $A^{\zeta 38}$.

*12. A crater south of IV $A^{\zeta 1}$. G of B. & M.? Longer axis W.S.W.–E.N.E. 8″·56; shorter axis N.N.W.–S.S.E. 6″·66, mag. 0·46.

Although a point of the second order, this crater appears to be wrongly placed by B. & M. There does not appear to be a crater either on the photograph of February 22, 1858, or on Lohrmann's Section I., between IV $A^{\zeta 1}$ and the angle formed by the walls of Albategnius and Ptolemæus. In this angle on the photograph is a crater, which I take to be B. & M.'s G. The position of second order, 12 ×, comes upon its west margin.

13. The S.W. of three craterlets east of IV $A^{\zeta 1}$ 2″·85, mag. 0·18. f of B. & M.

14. The middle of three craterlets east of IV $A^{\zeta 1}$ 2″·85, mag. 0·18.

†15. The N.E. of three craterlets east of IV $A^{\zeta 1}$.

These craterlets lie in a line from the east border of IV $A^{\zeta 1}$ to the rocky order of Ptolemæus. On Sept. 22, 1864, these three were recorded, with a robable fourth. B. & M. give *six*, and say, in 'Der Mond,' p. 346, "a row f six craters." 1865, Jan. 5, *four* are quoted by Mr. Freeman of Mentone, with two very small ones. 1866, Feb. 22, I found five. The additional ones are IV $A^{\zeta 18}$ and IV $A^{\zeta 19}$.

**16. The mountainous west border of Ptolemæus. Lohrmann, Sec. I. 16.

**17. A mountain on the west border of Ptolemæus forms a terrace intermediate in altitude and position between the high rugged land at the N.E. of Albategnius and the smooth surface of Ptolemæus, and has a slight, but very perceptible, depression on its summit, which is not unlike a tableland. West of it is the deep hollow IV $A^{\zeta 97}$.

†18. A small craterlet N.E. of IV $A^{\zeta 15}$.

†19. A small craterlet N.E. of IV $A^{\zeta 18}$.

These two craterlets complete the record of the crater-row from IV $A^{\zeta 1}$ to IV $A^{\zeta 16}$. Mr. Knott considers that IV $A^{\zeta 19}$ is not a craterlet, but only a rise in the ground, which produces a craterlike appearance.

This crater-row may now be considered as well determined, and with the dimples IV $A^{\zeta 8}$, IV $A^{\zeta 9}$, will constitute a crater-rill, according to Schmidt, although not found in his catalogue. It is noteworthy that it occurs on the line of cliffs extending from Halley to Ptolemæus, which is broken by IV $A^{\zeta 1}$, IV $A^{\zeta 4}$. IV $A^{\zeta 32}$ is common to two lines of cliffs, which cross each other nearly at right angles. The magnitudes of IV $A^{\zeta 15}$, IV $A^{\zeta 18}$, IV $A^{\zeta 19}$ have not been determined nor estimated. The length of the crater-rill from IV $A^{\zeta 13}$ to IV $A^{\zeta 19}$ inclusive is 15″·22. It is not in Lohrmann.

‡20. A furrow on the interior slope of the S.E. rim of IV $A^{\zeta 1}$, length 10″·94.

This furrow was discovered on the 6th of December, 1864, by the Rev. T. W. Webb, who thus mentions it in a letter under date of the 7th of December, 1864. Speaking of the row of craters extending from IV $A^{\zeta 1}$ to Ptolemy, he says, "There are but four, or at most five craters in their [B. & M.'s] row of six. I could readily count them but for the great agitation of the air; the S.W. one, which seems to be Albategnius f of the map, is the largest; they decrease somewhat towards Ptolemæus. The direction S.W. is carried on by a furrow (I presume one of your dimples) through the wall, and visible on its *interior* slope to the junction of the two subcraters on the S.W. side of X (IV $A^{\zeta 1}$)."

On the 5th of January, 1865, Mr. Freeman at Mentone, the Alpes Maritimes, examined this locality, but could not find the furrow. Of the crater-row he says, "The four were too nearly in a direct line with IV $A^{\zeta 5}$ to enable a furrow *within* the ring of 235 (L.) to connect them."

On February 22, 1866, I obtained at Hartwell, with the equatoreal of 5·9-inches aperture, a view of Mr. Webb's furrow; my observation is thus recorded:—"I saw also distinctly Mr. Webb's *furrow* on the interior of the S.E. border of X (IV $A^{\zeta 1}$), which is a continuation of the crater-row, in which at least there are five craters."

The existence of this furrow is accordingly confirmed, although it would

seem that its appearance or visibility is *rare*, being seen, as many other objects are, only under particular angles of incidence and visual ray. Mr. Knott examined the locality on the 23rd and 24th of February, 1866. He does not mention it in his record, but says that "Mr. Freeman's description of this region tallies better with my own seeings than that of Mr. Webb."

It is not unlikely that the S.E. rim of Lohrmann's X (IV $A^{\zeta 1}$) may possess such a configuration as sometimes to throw the furrow out of sight. This might be produced by the interior slope being presented to the eye nearly in a vertical line. It clearly appears that this object may be placed amongst the most delicate and fugitive of the lunar features.

†21. A small crater east of IV $A^{\zeta 7}$.

This crater appears on the photograph as elliptical? The longer axis, E.–W., 4″·76; the shorter, N.–S., 2″·85; mag. 0·23. It may be regarded as a craterlet. Lohrmann gives *two* here, none on the W.

†22. A craterlet west of IV $A^{\zeta 7}$ 2″·38, mag. 0·16.

Mr. Freeman mentioned these craterlets to me in a letter bearing date 1865, January 21. On the 22nd of February, 1866, at Hartwell, I recorded an observation of them, and remarked that B. & M. gave only the east crater. I, however, find in their map, close to the west border of IV $A^{\zeta 7}$, a very small crater, and if the two be intended by B. & M. for the craters seen by Mr. Freeman and by me, the position of one, if not both, requires to be more accurately determined. They are given on the map as they align in the photograph. B. & M.'s craters lie S.E. and N.W. Mr. Freeman and I give them as seen in the telescope, east and west. 1867, March 15, seen as on map.

23. The highest (?) point of the west border of Ptolemæus.

Well shown by Lohrmann both in his map and Section I., but indifferently by B. & M. The mountain presents a fine, bold and steep front W.N.W. to the high land situated in the angle between Albategnius and Ptolemæus, and extends N.N.E. to about the middle of IV $A^{\zeta 77}$. Length from the west edge of IV $A^{\zeta 72}$ to the promontory opposite IV $A^{\zeta 77}$ 13″·79. At its W.N.W. foot is a valley, IV $A^{\zeta 78}$, somewhat wide at first, but which gradually contracts towards the N.N.E., and terminates at a point where the rill, IV $A^{\zeta 79}$, which furrows the slope of IV $A^{\zeta 23}$, also terminates.

*24. A plain west of Herschel (III $A^{\zeta 1}$), the S.W. part.

There are several objects on this plain. See p. 279, IV $A^{\zeta 104}$, &c.

**25. The formation between Halley IV $A^{\eta 4}$ and IV $A^{\zeta 1}$.

This is a very individualized formation on the south part of Hipparchus, measuring N.N.W.–S.S.E. from IV $A^{\zeta 80}$–IV $A^{\zeta 32}$ inclusive, 37″·09, and W.S.W.–E.N.E. from IV $A^{\zeta 29}$–IV $A^{\zeta 6}$ inclusive, about 34″. Its boundary on the S.W. and south consists of a mountainous border, springing from the mountain IV $A^{\zeta 29}$ on the east border of Halley, which forms the N.W. part of the mountain-chain separating Albategnius from Ptolemæus, and of which the mountain IV $A^{\zeta 26}$ is the highest point. The N.W. (IV $A^{\zeta 27}$) and N.E. boundaries appear to be depressed below the general surface, the N.W. somewhat in the nature of a rill with two elevations, IV $A^{\zeta 56}$, IV $A^{\zeta 57}$, on the S.E. side; the N.E. has somewhat the appearance of a crater-row, two craters being very apparent, IV $A^{\zeta 60}$ and IV $A^{\zeta 46}$; in addition there are two mountains, IV $A^{\zeta 28}$ and IV $A^{\zeta 61}$. At the east extremity of this formation

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s the crater IV $A^{\zeta 6}$, which is opened up in the rising and elevated ground forming the east boundary. This elevated ground fills the angle between Albategnius and Ptolemæus, and is marked "higher level."

The interior surface of IV $A^{\zeta 25}$ is slightly depressed and irregular. It is marked "lower level (2)," indicating that it is lower than the surface of Hipparchus "lower level (1)." On the west portion are two conspicuous mountains, one, IV $A^{\zeta 30}$, in the angle formed by the S.W. and N.W. boundaries, and also in a line with the mountain IV $A^{\zeta 29}$ and the crater IV $A^{\zeta 6}$; the other, IV $A^{\zeta 31}$, N.E. of IV $A^{\zeta 30}$, and forming with it *two* elevations nearly parallel with the depression or broad rill, IV $A^{\zeta 27}$.

The mountain IV $A^{\zeta 32}$ forms the continuation of the east boundary from IV $A^{\zeta 6}$. There are two (apparently) elevations, one nearly between IV $A^{\zeta 30}$ and IV $A^{\zeta 32}$ (IV $A^{\zeta 71}$), the other between IV $A^{\zeta 31}$ and IV $A^{\zeta 6}$.

There are three conspicuous craters on this formation; one, IV $A^{\zeta 44}$, S.W. of IV $A^{\zeta 6}$, and two N.W. of IV $A^{\zeta 6}$, viz. IV $A^{\zeta 45}$ and IV $A^{\zeta 46}$, at the south foot of IV $A^{\zeta 28}$.

26. The mountain on the S.W. boundary of IV $A^{\zeta 25}$.

27. A valley forming the N.W. boundary of IV $A^{\zeta 25}$, length from IV $A^{\zeta 29}$ to IV $A^{\zeta 57}$ 25″·68.

*28. A cliff forming part of the N.E. boundary of IV $A^{\zeta 25}$, length W.N.W.–E.S.E. 10″·94.

**29. A mountain on the east border of Halley, height according to B. and M. 3543 English feet or 1080 metres; it has a spur towards the N.E.; length of spur 7″·13.

This mountain is very suitable for a point of the first order. The spur towards the N.E. inclines very considerably to the level of the valley IV $A^{\zeta 27}$. As the sun rises upon it, it is seen as a fine line of light.

*30. A mountain on the west floor of IV $A^{\zeta 25}$, length 8″·56.

*31. A mountain on the north floor of IV $A^{\zeta 25}$, length 8″·56.

*32. A mountain nearly S.S.W. of IV $A^{\zeta 6}$ 4″·28, mag. 0·29.

This mountain is longer than shown in the photograph. It is situated on the line of cliffs from Tycho, and extends nearly as far north as IV $A^{\zeta 6}$. It is the N.E. spur of Lohrmann's 20, Sec. I. East of and parallel with it is a crater-rill containing three adjoining craterlets, IV $A^{\zeta 90}$, IV $A^{\zeta 91}$, and IV $A^{\zeta 92}$. Another crater-rill branches from IV $A^{\zeta 91}$ to IV $A^{\zeta 43}$, containing two adjoining craterlets, IV $A^{\zeta 93}$ and IV $A^{\zeta 94}$.

**33. A craterlet at the extreme north point of Albategnius 3″·80, mag. 0·26. It is opened on the crater rill IV $A^{\zeta 67}$, at its western end.

**34. A pear-shaped depression, as seen, under some aspects, on the north part of Albategnius, opening into a crater on IV $A^{\lambda}$, of which it forms the north part.

This is imperfectly shown both by B. & M. and Lohrmann. It contains three craters, the south and largest, IV $A^{\lambda 17}$, the middle one, IV $A^{\zeta 50}$, and the north, IV $A^{\zeta 41}$.

35. Albategnius, the north part.

**36. A crater on the N.E. border of Albategnius, length 8″·56. Its real form requires to be determined. Shown by Lohrmann.

*37. A mountain appearing as a bright spot just N.E. of IV $A^{\zeta 25}$ length N.N.W.–S.S.E. 11″·41. Well shown by Lohrmann.

38. A cliff (apparently) on the high land crossing Hipparchus. It is on a "ray from Tycho." Not in Lohrmann.

39. A bright spot S.S.W. of IV $A^{\alpha 7}$. See IV $A^{\alpha 17}$.

40. An isolated craterlet between IV $A^{\zeta 10}$ and IV $A^{\zeta 33}$ 3″·81, mag. 0·22.

41. A crater just S.E. of IV $A^{\zeta 33}$, 6″·6, mag. 0·41.

This crater, of nearly the same superficial extent as IV $A^{\zeta 52}$, which adjoins it on the south-east, differs from IV $A^{\zeta 52}$ in an important particular: IV $A^{\zeta 41}$ has a *narrow* border, and appears to be *deeper* than IV $A^{\zeta 52}$, which is a shallower pit in a broad border, a class of crater of rather common occurrence on the moon's surface. The magnitude of IV $A^{\zeta 52}$, 0·42, includes the broad border. IV $A^{\zeta 41}$ is remarkable for its apparent priority to the crater-rill IV $A^{\zeta 67}$, which cuts completely through it, rendering the north part brilliantly white, while the surface tint of the south part is dark. It would appear that the north part of IV $A^{\zeta 41}$ has been *raised*, the crater-rill IV $A^{\zeta 67}$ occupying the very summit of the wall of Albategnius (see IV $A^{\zeta 82}$), from which the south slope is very steep. The crater is shown by Lohrmann.

42. A craterlet a little N.N.W. of IV $A^{\zeta 36}$ 3″·80, mag. 0·25; situated on the W.S.W. slope of the cliffs crossing Hipparchus.

*43. A craterlet between IV $A^{\zeta 36}$ and IV $A^{\zeta 4}$ 4″·76, mag. 0·29.

44. A craterlet W.S.W. of IV $A^{\zeta 6}$ 3″·33, mag. 0·23; situated on the W.S.W. slope of the cliffs crossing Hipparchus.

45. A craterlet N.W. of IV $A^{\zeta 6}$ 4″·76, mag. 0·29.

46. A craterlet N.N.E. of IV $A^{\zeta 45}$, estimated 3″·20, mag. 0·19.

**47. The west mountainous border of IV $A^{\zeta 24}$, length N. by W.–S. by E. 18″·07. Well shown by Lohrmann.

48. A short mountain-range between IV $A^{\zeta 7}$ and IV $A^{\zeta 47}$, length N. by W.–S. by E. 14″·74. Shown by Lohrmann.

*49. A craterlet on the south extremity of IV $A^{\zeta 47}$ 3″·33, mag. 0·25. It is situated on the east side of the end of the mountain-arm, and is the c of B. & M., but not shown by Lohrmann.

50. A crater on the north of Albategnius, between IV $A^{\zeta 34}$ and IV $A^{\zeta 41}$, 5″·23, mag. 0·32. Shown by Lohrmann.

This is the middle one of the three craters which make up the pear-shaped depression as seen under some aspects on the north of Albategnius. See IV $A^{\zeta 34}$. It is not difficult with a suitable aperture and power.

51. A crater between IV $A^{\zeta 10}$ and IV $A^{\zeta 34}$. 5″·23, mag. 0·33.

*52. A crater east of IV $A^{\zeta 50}$ adjoining it. 7″·13, mag. 0·42.

53. A crater-form depression between IV $A^{\zeta 50}$ and IV $A^{\zeta 51}$.

54. An elongated depression between IV $A^{\zeta 5}$ and IV $A^{\zeta 36}$; length S.S.W.–N.N.E. 8″·56, breadth uncertain, under 5″.

This depression occurs in the high land which fills the angle between Ptolemæus and Albategnius, and is S.E. of IV $A^{\zeta 25}$; the direction—N.N.E.–S.S.W. (somewhat inclining east and west) of IV $A^{\zeta 54}$—is similar to that of numerous rents and fissures in this and other parts of the moon, and

may probably be connected with the easternmost of the two "Ray-centres" in the neighbourhood of Furnerius. This System of Rays appears almost to rival that from Tycho in magnificence, but as it is nearer the limb than Tycho, the rays which issue from the centre are not so apparent. There is also this peculiarity: a ray, which may be regarded as central, passes in a nearly rectilineal direction towards the central part of the visible hemisphere, passing the north of Fracastorius and between Theophilus and Cyrillus to Alfraganus, and is lost apparently in the light ground that surrounds Alfraganus; but many of the irregularities of the surface, even as far as the rocky land bordering the smoother surface on which Triesnecker is opened, partake of the same direction, *i. e.* mountains and ridges in the neighbourhood of Godin and Agrippa are directed towards this ray-centre, and even the lateral valleys of the Apennines manifest the same general arrangement.

The rays issuing from the ray-centre above-mentioned towards the north and south bend so as to form branches of parabolic curves, and it is this feature which constitutes the peculiarity before alluded to.

The parallelism of the valleys IV $A^{\zeta 17}$, IV $A^{\zeta 54}$, and III $A^{\zeta 2}$ appears to connect them with this system; for although the general direction of these valleys is not immediately towards the ray-centre, yet they appear to form portions of the prolongations of rays that converge to it.

IV $A^{\zeta 54}$ coincides with and is prolonged in a line of upheaval passing through IV $A^{\zeta 5}$, IV $A^{\zeta 1}$ (east side), IV $A^{\zeta 48}$, IV $A^{\zeta 49}$, III $A^{a 2}$ (west side), and the east boundary of Reaumur. See IV. S.S.W.–N.N.E., p. 272.

*55. A craterlet on the floor of Ptolemæus, between the mountains IV $A^{\zeta 17}$, IV $A^{\zeta 16}$ 3″·33, mag. 0·19. Well shown by Lohrmann.

*56. A mountain on the S.E. side of IV $A^{\zeta 27}$, length S.S.W.–N.N.E. 9″·79.

57. A mountain near the N.E. extremity of IV $A^{\zeta 27}$, length S.S.W.–N.N.E. 5″·23.

These mountains, with the N.E. spur of IV $A^{\zeta 29}$, form the S.E. boundary of the valley IV $A^{\zeta 27}$; it is uncertain if the mountains be isolated or connected by low ridges, but it appears probable that the surfaces of the valley IV $A^{\zeta 27}$ and the depression IV $A^{\zeta 25}$ are at the same level, and that together they form the lowest portion of Hipparchus, the levels of Ptolemæus and Albategnius being considerably lower.

*58. A curved mountain-chain on the floor of Hipparchus, west of the cliff IV $A^{\zeta 38}$. It is concentric with the S.W. border of Hipparchus. Diameter N.W. to S.E. 20″·45.

There is great reason to believe that this formation is an *ancient* and *partly filled* crater with a very broken wall, as under an oblique illumination its surface is seen to be depressed, and it presents the crater character. The craterlet IV $A^{\zeta 100}$ appears to form a point in the line of ancient wall.

59. A craterlet at the S.W. extremity of the mountain-arm enclosing the plain IV $A^{\zeta 24}$, III $A^{\zeta 14}$ on the south. Diameter east to west 4″·76, north to south 2″85, mag. 0·23. It requires further observation.

*60. The mountain-range between IV $A^{\zeta 59}$ and III $A^{\zeta 2}$, length S.S.W.–N.N.E. 13″·31.

*61. A mountain north of IV $A^{\zeta 6}$ 8″·08. Lohrmann 34, Sec. I.

IV $A^{\zeta 37}$ and IV $A^{\zeta 61}$ are two conspicuous mountains, with the valley

IV $A^{\zeta 85}$ between them, situated on the N.W. border of the plain in which the group IV $A^{\zeta 1}$ and surrounding objects are situated.

‡62. A minute craterlet at the S.W. end of IV $A^{\zeta 27}$, estimated 1″, mag. 0·06.

‡63. A minute craterlet N.E. of IV $A^{\zeta 62}$, estimated 1″·0, mag. 0·06.

‡64. A minute craterlet N.E. of IV $A^{\zeta 63}$, estimated 1″·0, mag. 0·06.

These minute craterlets form a short crater-row at the closed extremity of the valley IV $A^{\zeta 27}$. They are inserted on the authority of Lohrmann, who mentions them in his text, "Topographie der Sichtbaren Mondoberfläche," Erste Abtheilung, auf Section I. p. 49, A. I have not yet seen them. Estimated length of crater-row 5″·0.

*65. A crater-form depression S.E. of Halley. 48, Sec. I. of Lohrmann. Length S.S.W.–N.N.E. 16″·64, breadth W.N.W.–E.S.E. 7″·61.

66. A depression in which the mountain IV $A^{\zeta 26}$ is situated. 7″·61, mag. 0·46. Not shown by Lohrmann.

**67. A crater-rill on the summit of the N.E. wall of Albategnius, discovered as such by Schmidt, on February 3rd, 1865. It is No. 355 in his 'Catalogue of Rills,' and extends from the west edge of IV $A^{\zeta 33}$ to IV $A^{\zeta 36}$, length W.N.W.–E.S.E. 21″·40.

This crater-rill forms the N.E. boundary of the group of craters in the north angle of Albategnius, and would appear to be the most recent instance of volcanic action in this locality, except the fault from Tycho. Its extreme *whiteness*, as compared with the surface in its neighbourhood, the steepness of its S.S.W. and N.N.E. sides, and particularly its *cutting through* the crater IV $A^{\zeta 41}$, testify to the comparative recent epoch of its formation. See IV $A^{\zeta 82}$. It is a fine object at sunrise.

68. A craterlet on IV $A^{\zeta 67}$ east of IV $A^{\zeta 41}$. 2″·61, mag. 0·15.

69. A crater-form depression on the W.S.W. slope of the line of cliffs which cross the N.E. angle of Albategnius in a line with those crossing Hipparchus; it is situated just S.S.E. of IV $A^{\zeta 36}$. 7″·13, mag. 0·42. It is shown by Lohrmann.

70. A crater-form depression on the E.N.E. side of the same line of cliffs 7″·61, mag. 0·50. It is shown by Lohrmann.

‡71. A formation, somewhat of the character of a trapezium, on the line of cliffs extending from IV $A^{\zeta 32}$ to IV $A^{\zeta 29}$. It has a bright border with a dark interior. Length, N.W. to S.E., 7″·61; breadth, S.W. to N.E., 4″·76.

†72. A depression on IV $A^{\zeta 23}$, apparently a crater. Elliptical, longer axis, east to west 8″·56; shorter, north to south 5″·71, mag. 0·44.

This depression was seen, 1866, Sept. $19^{d}$ $8^{h}$ $0^{m}$, G.M.T., with the Royal Society's $4\frac{1}{4}$-inch achromatic, power 230, as a very imperfect crater; the north rim appeared nearly perfect, but the south rim, if it previously existed, has been broken away by the convulsion that produced the deep hollow IV $A^{\zeta 97}$. It is not shown by Lohrmann.

73. A small depression (not craterlet) in the elevated angle between IV $A^{\zeta 69}$ and IV $^{\zeta 36}$. 2″·38, mag. 0·16.

74. A craterlet on the crater-rill IV $A^{\zeta 82}$, just east of IV $A^{\zeta 69}$ and IV $A^{\zeta 36}$, 4″·28, mag. 0·26. Lohrmann gives it larger than IV $A^{\zeta 86}$.

*75. A mountain south of IV $A^{\zeta 12}$, at the S.E. end of the crater-rill IV $A^{\zeta 82}$, 5″·23, mag. 0·31.

†76. A slight elevation, somewhat similar to a circular tableland, east of the depression IV $A^{\zeta 54}$, 5″·23, mag. 0·31. Not in Lohrmann.

**77. The slope of IV $A^{\zeta 16}$ fronting the west, and south of IV $A^{\zeta 3}$, length S.S.W.–N.N.E. 12″·84. Lohrmann, Sec. I. 16.

78. The valley at the W.N.W. foot of IV $A^{\zeta 23}$, nearly parallel with IV $A^{\zeta 54}$, length, S.S.W.–N.N.E., 12″·84.

79. A rill furrowing the N.E. portion of the W.N.W. slope of IV $A^{\zeta 23}$; it communicates with the N.N.E. end of the valley IV $A^{\zeta 78}$, length 6″·18; discovered July 21, 1866, by the author on Rutherford's Photograph, and seen with the Royal Society's 4¼-inch refractor, power 230, on the 18th of August, 1866.

80. A crater-form depression at the N.W. extremity of the N.E. boundary of IV $A^{\zeta 25}$ 5″·23, mag. 0·31. Not in Lohrmann.

81. A rill extending from the angle formed by the N.E. borders of IV $A^{\zeta 80}$ and IV $A^{\zeta 28}$ to a point east of the cliff IV $A^{\zeta 38}$ 16″·17. I do not find it in Schmidt's 'Catalogue of Rills;' it was discovered, July 21, 1866, on Rutherford's Photograph.

This rill is in continuation of the line of cliffs that crosses Albategnius and IV $A^{\zeta 25}$. The elevations forming the N.E. border of IV $A^{\zeta 25}$ have apparently slightly *heaved* the line of cliffs, and probably produced the rill, which runs but for a short distance. After crossing the central parts of Hipparchus, the cliffs, which to the south present their faces to the W.S.W., have them to the north, facing steeply the E.N.E. as well as W.S.W. on the borders of IV $A^{*10}$ and Rhæticus. The whole line of cliffs is well marked, extending from the east border of Albategnius to a point N.E. of Agrippa.

82. A crater-rill on the N.E. wall of Albategnius 16″·17. It is probably No. 354 of Schmidt's 'Catalogue of Rills.' If so, it was discovered by him on the 17th of August, 1843. It is in the same line with IV $A^{\zeta 67}$, and most probably the two formed one continuous crater-rill at an earlier epoch than that of the protrusion of the line of cliffs crossing IV $A^{\zeta 25}$ and Hipparchus, at which period the crater-rill was separated into the two portions, IV $A^{\zeta 67}$ and IV $A^{\zeta 82}$.

The earlier discovery of this rill, combined with the brightness and steepness of IV $A^{\zeta 67}$, which Schmidt did not discover until February 3, 1865, appears to point to a probable brightening and raising of IV $A^{\zeta 67}$ within the twenty-two years, otherwise the oversight of IV $A^{\zeta 67}$ by Schmidt in 1843 is remarkable.

83. A valley parallel with IV $A^{\zeta 78}$, but a little more than half its length. Length, S.S.W. to N.N.E., 8″·08.

84. A valley in the west border of Ptolemæus opening out to the plain between the mountains IV $A^{\zeta 17}$ and IV $^{\zeta 16}$, and running with a gradual ascent between IV $A^{\zeta 23}$ and IV $A^{\zeta 16}$, to the high land bounded by the crater-rill IV $A^{\zeta 13}$ to IV $A^{\zeta 19}$; length about 16″·0.

85. A valley between the two high mountains IV $A^{\zeta 61}$ and IV $A^{\zeta 37}$, length 64″·67.

This valley opens out into a shallow sinuous valley that crosses Hipparchus just east of the line of cliffs, and enters a mountain-gorge just east of IV $A^{\zeta 10}$: the opening into the shallow valley on the plain of Hipparchus is partly obstructed by some low hills. The shallow valley is provisionally shown on the map, as it is not discernible on the photograph, and good drawings of it are required. It is only visible just after the passage of the morning, or just before the passage of the evening terminator, and is marked with a ‡.

86. A small detached mountain N.W. of IV $A^{\zeta 37}$ 3″·33.

87. A small depression at the foot of IV $A^{\zeta 75}$ 3″·33, mag. 0·20.

88. An imperfect crater between IV $A^{\zeta 31}$ and IV $A^{\zeta 58}$ 5″·71, mag. 0·34.

†89. A ridge connecting IV $A^{\zeta 76}$ with IV $A^{\zeta 5}$, length 7″·5.

90. A craterlet S.E. of the mountain IV $A^{\zeta 32}$. It is the most southern of three, forming a crater-rill, estimated at 3″·0.

91. An elongated crater east of the mountain IV $A^{\zeta 32}$ between IV $A^{\zeta 90}$ and IV $A^{\zeta 92}$, estimated at 5″·0.

92. A craterlet just south of IV $A^{\zeta 6}$, the most northern of the crater-rills east of IV $A^{\zeta 32}$, estimated at 2″·5.

The above *three* objects form a crater-rill, estimated length 11″·0, not in Schmidt's printed Catalogue; it was discovered by the author on the 18th of August, 1866. Lohrmann has *four* craterlets here.

93. A craterlet N.W. of and adjoining IV $A^{\zeta 43}$; it is the south-eastern of a crater-rill between IV $A^{\zeta 43}$ and IV $A^{\zeta 32}$, estimated at 2″·5.

94. A craterlet between IV $A^{\zeta 91}$ and IV $A^{\zeta 93}$, estimated at 2″·6.

IV $A^{\zeta 91}$, IV $A^{\zeta 94}$, IV $A^{\zeta 93}$, and IV $A^{\zeta 43}$ form a crater-rill, estimated length 11″·5; not in Schmidt's printed Catalogue. It was discovered by the author on the 18th of August, 1866. Lohrmann gives a mountain.

95. A craterlet just south of IV $A^{\zeta 4}$, estimated at 2″·5.

This craterlet, with IV $A^{\zeta 43}$, is in a line with the crater-row IV $A^{\zeta 13}$ to IV $A^{\zeta 19}$, and a little inclined southwardly to the line of depression III. W.S.W.–E.N.E.; Webb's furrow IV $A^{\zeta 20}$ is in the same line. It is not shown either by Lohrmann or B. & M.

96. A valley extending from IV $A^{\zeta 48}$ to IV $A^{\zeta 47}$ in the direction S.S.W.–N.N.E. It is not inserted in the map, as it has only been observed once, when its outline was not ascertained. It is slightly west of the line of depression and upheaval V. S.S.W.–N.N.E.

97. A deep hollow of a very irregular form in the high land between Albategnius and Ptolemæus. It is situated, west to east, between the mountains IV $A^{\zeta 75}$ and IV $A^{\zeta 17}$, and north to south between the north rim of IV $A^{\zeta 72}$ and the high land between the east border of Albategnius and the S.W. border of Ptolemæus. Its interior W. and N.W. slopes, which are very rugged, form the precipitous descents from the summits of IV $A^{\zeta 75}$, the S.E. rim of IV $A^{\zeta 12}$, and the broken portion of IV $A^{\zeta 72}$; the west front of IV $A^{\zeta 17}$, which does not appear to be so rugged, forms its interior east slope. It is not shown by Lohrmann.

98. A steep point in the N.W. border of Ptolemæus just north of IV $A^{\zeta 3}$; it is indicated on B.&M.'s map by $\eta$. Their measures give

8672 English feet, or 2643 metres for its altitude. It appears to be on the line of cliffs on which the crater-row IV $A^{\zeta 13}$ to IV $A^{\zeta 19}$ is situated.

99. The steep interior slope of the east rim of Halley, the west foot of the mountain IV $A^{\zeta 29}$, is distinctly visible on the floor of Halley as a curve projecting inwards.

100. A craterlet on the north border of IV $A^{\zeta 38}$ 1″·9, mag. 0·16.

101. A furrow crossing IV $A^{\zeta 58}$, at the foot of the cliff IV $A^{\zeta 38}$. The foot of the cliff with further indications of the furrow is continued past IV $A^{\alpha 18}$ to the west edge of IV $A^{\alpha 10}$. It was discovered by the author, Nov. 2, 1866, on Rutherford's photograph.

102. A light spot just east of the valley IV $A^{\zeta 85}$ 3″·8, mag. 0·21.

The strip of surface east of the valley appears as a "ray" from IV $A^{\zeta 37}$. It is on this ray that IV $A^{\zeta 102}$ is situated.

[103.] IV $A^{\eta 28}$, a crater or depression on the west side of IV $A^{\zeta 58}$. It needs further and careful observation. See p. 279, IV $A^{\zeta}$.

Summary of Rills, Crater-rows, and Valleys registered as above not in Schmidt's printed Catalogue:—

| | | | |
|---|---|---|---|
| S. | to | N. | IV $A^{\zeta 90}$ to IV $A^{\zeta 92}$. Crater-row, discovered August 18, 1866. |
| S. | to | N. | IV $A^{\zeta 101}$. Furrow discovered November 2, 1866. |
| S.S.W. | to | N.N.E. | IV $A^{\zeta 62}$ to IV $A^{\zeta 64}$. Crater-row*. |
| W.S.W. | to | E.N.E. | IV $A^{\zeta 13}$ to IV $A^{\zeta 19}$. Crater-row. |
| N.W. | to | S.E. | IV $A^{\zeta 43}$ to IV $A^{\zeta 91}$. Crater-row, discovered August 18, 1866. |
| N.W. | to | S.E. | IV $A^{\zeta 79}$. Rill discovered July 21, 1866. |
| N.N.W. | to | S.S.E. | IV $A^{\zeta 81}$. Rill discovered July 21, 1866. |
| N.N.W. | to | S.S.E. | IV $A^{\zeta 84}$. Valley. |
| N.N.W. | to | S.S.E. | IV $A^{\zeta 85}$. Valley. |

## Area IV $A^{\alpha}$. *Full-Moon Aspect.*

One of the most interesting features of this area under the full-moon aspect is the portion of a "ray from Tycho," which traverses it from N.N.W. to S.S.E., and is coincident with the surface west of Rhæticus, and also west of the depression IV $A^{\alpha 10}$. The mountains IV $A^{\alpha 37}$, the cliff IV $A^{\alpha 14}$, and the south-west extremity of the valley IV $A^{\alpha 32}$ are crossed by this ray as well as the west boundary of IV $A^{\alpha 10}$. As the ray passes east of Horrox and crosses the floor of Hipparchus, it is intersected by a short ray *from* Horrox towards E.S.E., which includes the depression IV $A^{\alpha 7}$.

The depressed surface IV $A^{\alpha 11}$ around the crater IV $A^{\alpha 4}$, which is a bright spot at the time of full moon, exhibits a variety of middle tints that appear to be *unconnected* with any definite objects, as none are found corresponding with them when IV $A^{\alpha 11}$ is near the terminator.

* Inserted on the authority of Lohrmann.

Between IV $A^{\alpha 11}$ and the "ray from Tycho" is a dark strip interrupted by the slope of IV $A^{\alpha 50}$. This dark strip passes over the west of Rhæticus and extends south from Rhæticus to IV $A^{50}$. It is resumed in the depression IV $A^{\alpha 78}$, it crosses IV $A^{\alpha 39}$, and part of the valley IV $A^{\alpha 38}$, traverses the western interior of IV $A^{\alpha 10}$, crosses the middle of the valley IV $A^{\alpha 32}$, the south-west part of the depression IV $A^{\alpha 12}$, and is continued east of the bright ray from Tycho into the area IV $A^{\zeta}$.

The interior of Reaumur is dark in the full moon. The south-west part is crossed by a strip somewhat lighter than the general surface; the west and north-west mountain border is also somewhat lighter.

From the mountain IV $A^{\alpha 5}$ on the border of Reaumur the tint characterizing the mountain border extends as far as the spot IV $A^{\alpha 71}$, and includes the mountain IV $A^{\alpha 28}$. The crater-row? IV $A^{\alpha 7}$, IV $A^{\alpha 22}$, and IV $A^{\alpha 23}$, with the spot IV $A^{\alpha 17}$, IV $A^{\zeta 39}$, appear as a large bright spot, from which a portion of a line of disturbance from Tycho appears as a ray which extends to IV $A^{\zeta 77}$. This bright ray is skirted by a dark strip, which is very prominent, in consequence of a light-ray parallel with that which extends from IV $A^{\alpha 7}$ to IV $A^{\zeta 77}$. This parallel light-ray appears to take its rise from IV $A^{\alpha 4}$, and crosses IV $A^{\alpha 21}$, between IV $A^{\alpha 4}$ and IV $A^{\alpha 21}$; it is narrow, but from IV $A^{\alpha 21}$ it becomes broader and brighter as it traverses the surface between IV $A^{\alpha 21}$ and IV $A^{\alpha 51}$: it is continued along the east side of the mountain-arm IV $A^{\zeta 47}$ in area IV $A^{\zeta}$.

### IV $A^{\zeta}$. *Full-Moon Aspect.*

This area is crossed from N.N.W. to S.S.E. at the time of full moon by a portion of a "ray from Tycho" sensibly parallel with the "fault" IV $A^{\alpha 23}$, which is just east of, and thus nearly coincident with, the next westerly "ray from Tycho." Both rays traverse uneven ground of the nature of cliffs, having their slopes towards the west. In passing over the broken ground of IV $A^{\zeta 25}$ the east ray is much broken, but it recovers its brightness in traversing the uneven rocky interior of the north-east wall of Albategnius. A lucid arm from the crater Halley traverses the south-west slope of IV $A^{\zeta 26}$ and the crater-rill IV $A^{\zeta 67}$, in which IV $A^{\zeta 33}$ is conspicuous as a bright spot; it joins the "ray from Tycho" at the bright spot or crater IV $A^{\zeta 36}$, which appears to be the most elevated point of the north-east border of Albategnius. The crater IV $A^{\zeta 6}$ appears as a bright spot just east of the "ray from Tycho," while the group of craters IV $A^{\zeta 10}$, IV $A^{\zeta 51}$, IV $A^{\zeta 34}$, IV $A^{\zeta 40}$, IV $A^{\zeta 53}$, IV $A^{\zeta 50}$, IV $A^{\zeta 52}$ in the north-west angle of Albategnius presents a tint intermediate between the darker portions of the surface of this area and the bright rays. East of the "ray from Tycho" passing over IV $A^{\zeta}$, both the high land in the angle between Ptolemæus and Albategnius, and the surface east of the cliff IV $A^{\zeta 38}$ on the floor of Hipparchus, present the darkest tint, as well as a strip which, from the west of IV $A^{\zeta 47}$, extends to the west border of Ptolemæus. The east part of the mountain-arm IV $A^{\zeta 47}$ is bright in full moon. Between the dark spaces just mentioned we have bright spaces intermingled with middle tints; a bright

break not unlike a "ray," extending from IV $A^{\zeta 39}$ (a bright spot), crossing IV $A^{\zeta 48}$, where it becomes brighter than usual, still further crossing the crater-row east of IV $A^{\zeta 1}$, and proceeding to the high mountain IV $A^{\zeta 77}$ on the west border of Ptolemæus, has been identified with a portion of a line of disturbance from Tycho. The group IV $A^{\zeta 1}$, IV $A^{\zeta 4}$, IV $A^{\zeta 5}$, and IV $A^{\zeta 7}$ is also bright. It is worthy of remark that the general direction of these light and dark spaces is towards Tycho.

## Areas IV $A^{\alpha}$, IV $A^{\zeta}$.

*Directions of Rills, Crater-rills, Crater-rows, Valleys, Mountain-chains, &c.*

Since the year 1786 several endeavours have been made to render certain features of the moon's surface especial objects of study, particularly the rills, the first of which—the remarkable wedge-shaped valley of the Alps—was discovered by Bianchini on Sept. 22, 1727*. Lohrmann, Mädler, Kinau, and Schmidt have carried on the study of rills during the interim, and the number now known exceeds 425. In the admirable 'Catalogue of Rills' lately published by Schmidt, not only has the class been considerably augmented by including large valleys, of which the first-discovered rill may be regarded as the type, but the direction of each has been given in a very clear and distinct manner. I am not aware, however, that any attempt has been made to classify the "rills" according to direction, which may have an important bearing on the subject of the manifestation of the effects of those forces which have modified the surface; for there can be no doubt that while the crater-form is apparently by far the most prominent feature, the directions of the rills, valleys, crater-rows, and mountain-chains indicate the lines in which the forces modifying the surface operated, it may be over wide-spread areas around foci of disturbance, such as Tycho, and other ray-centres; consequently an arrangement of these directions may in some degree contribute to our knowledge of the operation of forces on a minor scale which may have modified the features of smaller portions of the surface.

It is not my intention to undertake a classification of the directions of Schmidt's 425 rills, but simply, as this work proceeds, to arrange under each artificial area of 5° of longitude by 5° of latitude the directions of rills, crater-rows, crater-rills, valleys, mountain-chains, or any feature that indicates the line in which the action of either upheaving or depressing forces has been manifested, thus laying the foundation of a more enlarged generalization at some future period.

In the following Table of lines of upheaval and depression in areas IV $A^{\alpha}$ and IV $A^{\zeta}$ the directions are expressed by the two opposite points of the lunar compass between which the line lies, regarding throughout the meridian as the starting line, and passing from south by west to north. In Quadrants I. and IV. the arrangement will be from the meridian westward, and in Quadrants II. and III. from the meridian eastward.

* Schmidt, in his 'Catalogue of Rills', ascribes the discovery of this interesting formation to Schröter, who noticed it 1787, October 1, and delineated it in his Selenotopographische Fragmente; but it was carefully observed by Bianchini on the date given in the text, and described and figured by him in his 'Hesperi et Phosphori Nova Phænomena,' printed at Rome in 1728. Bianchini mentions it as indicated in Cassini's chart.

| Direction. | Character. | Objects and Remarks. |
|---|---|---|
| S. by W.–N. by E. | 1. Depression .... | IV $A^{\alpha 60}$, IV $A^{\alpha 58}$, IV $A^{\alpha 12}$, IV $A^{\alpha 76}$. This line is continued in area IV $A^{\gamma}$ across Halley; it intersects S.S.W.–N.N.E. IV $A^{\zeta}$ No. 8 in the mountain IV $A^{\zeta 29}$, and merges into IV $A^{\gamma 42}$ and IV $A^{\gamma 17}$. |
| S. by W.–N. by E. | 2. Upheaval and depression. | IV $A^{\alpha 48}$, IV $A^{\alpha 10}$, IV $A^{\alpha 32}$. |
| S. by W.–N. by E. | 3. Upheaval and depression. | IV $A^{\alpha 37}$, IV $A^{\alpha 49}$, IV $A^{\alpha 18}$, IV $A^{\zeta 101}$. The three lines which differ slightly in their inclination to the meridian all converge to the mountain IV $A^{\zeta 29}$. |
| S. by W.–N. by E. | 4. Upheaval .... | IV $A^{\alpha 35}$, IV $A^{\alpha 39}$, IV $A^{\alpha 50}$, and the east border of Rhæticus. |
| S.S.W.–N.N.E. .. | 1. Depression and upheaval. | IV $A^{\alpha 7}$, IV $A^{\alpha 24}$, IV $A^{\alpha 29}$, IV $A^{\alpha 25}$, IV $A^{\alpha 21}$, IV $A^{\alpha 5}$. |
| S.S.W.–N.N.E. .. | 2. Depression and upheaval. | IV $A^{\alpha 24}$, IV $A^{\alpha 27}$, IV $A^{\alpha 29}$, IV $A^{\alpha 21}$. |
| S.S.W.–N.N.E. .. | 3. Upheaval and depression. | IV $A^{\alpha 28}$, IV $A^{\alpha 73}$, IV $A^{\alpha 16}$, IV $A^{\alpha 19}$, IV $A^{\alpha 64}$, IV $A^{\alpha 69}$. Also the lucid spot IV $A^{\alpha 71}$. These three lines are parallel with and close to each other, and agree in direction with three somewhat similar lines in area IV $A^{\zeta}$ on the *opposite side* of Hipparchus; viz. S.S.W.–N.N.E. IV $A^{\zeta}$ Nos. 8 and 9. See Table, p. 272, and the low hills on the N.W. side of the valley IV $A^{\zeta 27}$. The middle line S.S.W.–N.N.E. No. 2 of IV $A^{\alpha}$ and No. 9 of IV $A^{\zeta}$, can be traced on the S.S.W. in the direction of the crater C and ring d of R. & M. on area IV $A^{\mu}$. |
| S.S.W.–N.N.E. .. | 4. Depression and upheaval. | IV $A^{\alpha 20}$, IV $A^{\alpha 13}$, IV $A^{\alpha 76}$, IV $A^{\zeta 58}$, and the west border of Halley. |
| S.S.W.–N.N.E. .. | 5. Depression .... | IV $A^{\alpha 32}$, IV $A^{\gamma 18}$. The close coincidence of *direction* of the lines of depression and upheaval on the N.E. and S.W. sides of Hipparchus appears to point to a more recent epoch for the formation of the floor than that at which the mountainous border was produced, and the very general direction S.S.W.–N.N.E. of the lines of disturbance in this part of the moon points to a still earlier epoch, when the surface was dislocated in lines running S.S.W.–N.N.E. |
| W.N.W.–E.S.E. | 1. Depression and upheaval. | IV $A^{\alpha 14}$, IV $A^{\alpha 32}$, IV $A^{\alpha 12}$, IV $A^{\alpha 28}$, IV $A^{\alpha 7}$, IV $A^{\alpha 22}$, IV $A^{\alpha 23}$, IV $A^{\alpha 31}$. |
| W.N.W.–E.S.E. | 2. Depression and upheaval. | IV $A^{\alpha 14}$, IV $A^{\alpha 32}$, IV $A^{\alpha 12}$, IV $A^{\alpha 30}$, IV $A^{\alpha 13}$, IV $A^{\alpha 28}$, IV $A^{\alpha 26}$, IV $A^{\alpha 24}$, IV $A^{\alpha 52}$, IV $A^{\alpha 51}$. These lines form a range of cliffs which is parallel with the line W.N.W.–E.S.E. |

| Direction. | Character. | Objects and Remarks. |
|---|---|---|
| | | IV $A^{\zeta}$ 6 (see Table, p. 278) on the opposite part of Hipparchus, and separates the higher level of Hipparchus from the lower level of IV $A^{\alpha 11}$. If the two W.N.W.–E.S.E. ranges in IV $A^{\alpha}$ and IV $A^{\zeta}$ were contemporaneous in their origin, either the higher level of Hipparchus has been comparatively undisturbed, or the irregularities between the two lines of disturbance have been *overspread* subsequent to their formation; the apparently ancient crater which now appears as a wreath of disjoined mountains in IV $A^{\zeta 58}$ is significant in this respect. |
| N.W.–S.E. | 1. Upheaval and depression. | IV $A^{\alpha 6}$, IV $A^{\alpha 54}$, IV $A^{\alpha 67}$, IV $A^{\alpha 5}$, IV $A^{\alpha 16}$, IV $A^{\alpha 62}$, IV $A^{\alpha 63}$, IV $A^{\alpha 58}$, IV $A^{\alpha 59}$, IV $A^{\alpha 47}$.<br>This line forms part of a very extensive range of cliffs, which can be traced from the east border of Ptolemæus past the conspicuous crater Herschel I across the area IV $A^{\alpha}$, N.W. of the N.E. point of the border of Rhæticus, probably as far as the crater Menelaus, on the south border of the *Mare Serenitatis*. With the exception of the small portion forming the N.E. border of Ptolemæus which faces the S.W., the faces of the cliffs are directed towards the N.E. In the N.W. part the range is parallel with a portion of the Apennines.<br>In area IV $A^{\alpha}$ this line with W.N.W.–E.S.E. No. 2, and S. by W.–N. by E. No. 4 inclose a triangular space more or less disturbed in which the crater IV $A^{\alpha 4}$ is prominent. |
| N.W.–S.E. | 2. Upheaval and depression. | IV $A^{\alpha 15}$, IV $A^{\alpha 31}$, IV $A^{\alpha 7}$, IV $A^{\zeta 49}$, through the N.W. border of Ptolemæus to the crater on its floor. |
| N.N.W.–S.S.E. | 1. Upheaval? | IV $A^{\alpha 68}$, IV $A^{\alpha 69}$, IV $A^{\alpha 70}$.<br>This short line prolonged across Reaumur intersects W.N.W.–E.S.E. No. 2, and N.W.–S.E. No. 1, near IV $A^{\alpha 53}$. The crater in Ptolemæus is in the continuation of this line. |
| N.N.W.–S.S.E. | 2. Upheaval | IV $A^{\alpha 19}$, IV $A^{\alpha 64}$, IV $A^{\alpha 66}$.<br>This line is directed towards the west border of Thebit, and the east border of Purbach. |
| N. by W.–S. by E. | 1. Depression | IV $A^{\alpha 32}$, IV $A^{\alpha 10}$, IV $A^{\alpha 38}$, Rhæticus.<br>This line of *considerable* depression lies between the two faults IV $A^{\alpha 42}$ and IV $A^{\alpha 49}$. |
| S.–N. | 1. Upheaval and depression. | IV $A^{\zeta 90}$, IV $A^{\zeta 91}$, IV $A^{\zeta 92}$, IV $A^{\zeta 6}$, and IV $A^{\zeta 61}$.<br>A line principally of depression (craters). There is quite a knot of craters east of IV $A^{\zeta 32}$, forming apparently a *second* point of upburst on the "Ray from Tycho," the |

| Direction. | Character. | Objects and Remarks. |
|---|---|---|
| | | neighbourhood of IV A$^{26}$, and IV A$^{71}$ being the *first* as regards magnitude. |
| S.S.W.–N.N.E... | 1. Upheaval and depression. | IV A$^{97}$, IV A$^{72}$, IV A$^{23}$, IV A$^{77}$, IV A$^{1}$. This is a line of upheaval with a depression at each end in which the highest points—two mountains—are IV A$^{23}$ and IV A$^{16}$. It lies in the same direction as the east wall of Albategnius, and extends N.N.E. into area III A$^{5}$. |
| S.S.W.–N.N.E... | 2. Depression.... | IV A$^{87}$, IV A$^{12}$, IV A$^{78}$. In this line the crater IV A$^{12}$ is prominent. |
| S.S.W.–N.N.E... | 3. Depression.... | IV A$^{70}$, IV A$^{83}$. The crater-rill IV A$^{82}$ on the line W.N.W.–E.S.E. No. 2 c sees this line. |
| S.S.W.–N.N.E... | 4. Depression and upheaval. | IV A$^{69}$, IV A$^{74}$, IV A$^{54}$, IV A$^{5}$, and IV A$^{51}$ the east wall. This line is interrupted by the crater-rill IV A$^{82}$. |
| S.S.W.–N.N.E... | 5. Depression and upheaval. | IV A$^{34}$, IV A$^{52}$, IV A$^{42}$, IV A$^{43}$, IV A$^{54}$, IV A$^{1}$ the west wall, IV A$^{57}$. This line is separated into three portions by the line of upheaval and depression IV A$^{67}$ W.N.W.–E.S.E. No. 2, also by the line of upheaval N.N.W.–S.S.E. No. 6. |
| S.S.W.–N.N.E... | 6. Depression and upheaval. | IV A$^{34}$, IV A$^{50}$, IV A$^{41}$, IV A$^{6}$, IV A$^{57}$. This line prolonged N.N.E. will pass through IV A$^{61}$, as well as the point of upheaval IV A$^{32}$. |
| S.S.W.–N.N.E... | 7. Upheaval with depression. | IV A$^{65}$, IV A$^{66}$, IV A$^{26}$. This line is in continuation with the N.W. border of Albategnius. |
| S.S.W.–N.N.E .. | 8. Upheaval .... | Halley, the E. border IV A$^{29}$, IV A$^{56}$, IV A$^{57}$. This line is continued S.S.W. to the W. border of Albategnius. |
| S.S.W.–N.N.E... | 9. Depression.... | The valley IV A$^{27}$ with Lohrmann's three craterlets, IV A$^{62}$, IV A$^{63}$, IV A$^{64}$. |
| S.W.–N.E. .... | 1. Upheaval .... | IV A$^{60}$. |
| S.W.–N.E. .... | 2. Depression.... | IV A$^{10}$, IV A$^{40}$ IV A$^{33}$. |
| S.W.–N.E. .... | 3. Upheaval .... | IV A$^{30}$, IV A$^{31}$. These three lines are greatly separated on the area IV A$^{5}$. |
| W.S.W.–E.N.E. | 1. Depression.... | IV A$^{10}$, IV A$^{53}$, IV A$^{50}$, IV A$^{52}$, IV A$^{73}$, IV A$^{74}$, IV A$^{12}$, IV A$^{72}$, IV A$^{55}$. This is a line of craters and depressions, the longest on the area. It hardly assumes, however, the character of a continuous line of depression, although the craters and depressions are near each other, being interrupted by the line of upheaval N.N.W.– |

| Direction. | Character. | Objects and Remarks. |
|---|---|---|
| | | S.S.E. No. 5, and also crossed by the N.E. wall of Albategnius, which is identical with the line of upheaval and depression W.N.W.–E.S.E. No. 2, at the point of culmination IV $A^{\zeta 36}$. It is not unlikely that the two upheaving forces, whether contemporaneous in their action or otherwise, produced great disturbance in the north part of Albategnius, the result being the large group of craters in the south part of the area IV $A^{\zeta}$. The two main lines of disturbance are clearly W.N.W.–E.S.E. No. 2, N.N.W.–S.S.E. No. 5, of which N.N.W.–S.S.E. No. 5 appears to be the most recent. |
| W.S.W.–E.N.E. | 2. Upheaval .... | IV $A^{\zeta 26}$, IV $A^{\zeta 71}$, IV $A^{\zeta 32}$, IV $A^{\zeta 91}$. This line of upheaval is interrupted by the line N.N.W.–S.S.E. No. 5, and east of that line it curves into S.S.W.–N.N.E. No. 5. It forms a curve across the formation IV $A^{\zeta 25}$. |
| W.S.W.–E.N.E. | 3. Depression.... | IV $A^{\zeta 98}$, IV $A^{\zeta 2}$, IV $A^{\zeta 20}$, and the crater-row IV $A^{\zeta 13}$–IV $A^{\zeta 19}$. It would almost appear that this line of depression was due exclusively to the outbreak that produced IV $A^{\zeta 1}$ and its surrounding group of craters; but the line W.S.W.–E.N.E. No. 2 being in exactly the same direction, in fact a continuation of it, and not only so, for this same line is continued W.S.W. past Halley, and E.N.E. on the N.W. border of Ptolemæus, it would rather appear that the whole line of upheaval and depression resulted from the operation of a force that exerted itself over a much greater extent of area. |
| W.N.W.–E.S.E. | 1. Depression.... | IV $A^{\zeta 10}$, IV $A^{\zeta 51}$, IV $A^{\lambda 17}$, IV $A^{\lambda 18}$. |
| W.N.W.–E.S.E. | 2. Depression on a line of upheaval. | IV $A^{\zeta 67}$, IV $A^{\zeta 82}$. This line has been interrupted by the line N.N.W.–S.S.E. No. 5. It is formed of Schmidt's crater-rills Nos. 355, 354. |
| W.N.W.–E.S.E. | 3. Upheaval .... | IV $A^{\zeta 29}$, IV $A^{\zeta 26}$. Nos. 2 and 3 appear to be portions o the same line of fault; No. 3 being slightly N.E. of the continuation of No. 2, which indeed is continued on the N.W. side of Halley. |
| W.N.W.–E.S.E. | 4. Upheaval and depression. | IV $A^{\zeta 32}$, IV $A^{\zeta 91}$, IV $A^{\zeta 94}$, IV $A^{\zeta 93}$, IV $A^{\zeta 43}$. This appears to be of small extent and confined to the second point of upburst on the "Ray from Tycho." |
| W.N.W.–E.S.E. | 5. Depression.... | IV $A^{\zeta 6}$, IV $A^{\zeta 4}$, IV $A^{\zeta 5}$, and the S.E. mouth of the valley IV $A^{\zeta 84}$. |
| W.N.W.–E.S.E. | 6. Upheaval .... | IV $A^{\zeta 87}$, IV $A^{\zeta 80}$, IV $A^{\zeta 28}$, IV $A^{\zeta 61}$, IV $A^{\zeta 1}$ N. border, IV $A^{\zeta 16}$. |

| Direction. | Character. | Objects and Remarks. |
|---|---|---|
| | | These six lines traverse a nearly rectangular area, bounded on the S.S.W. by W.N.W.-E.S.E. No. 1, on the N.N.E. by W.N.W.-E.S.E. No. 6, on the W.N.W. by S.S.W.-N.N.E. No. 8, and on the E.S.E. by S.S.W.-N.N.E. No. 1. The area thus enclosed is the most disturbed in this part of the moon. |
| W.N.W.–E.S.E. | 7. Upheaval .... | IV $A^{\zeta 58}$ the longer axis. |
| N.W.–S.E. .... | 1. Rill..... | IV $A^{\zeta 79}$. This rill, which is not in Schmidt's Catalogue, was discovered on Rutherford's photograph by the author on July 21, 1866. It was observed with the Royal Society's telescope of 4¼-inch aperture, power 230, on August 18, 1866. It lies in the line W.N.W.–E.S.E. No. 5. |
| N.N.W.–S.S.E.. | 1. Valley ..... | IV $A^{\zeta 84}$. |
| N.N.W.–S.S.E.. | 2. Upheaval .... | IV $A^{\zeta 37}$, IV $A^{\zeta 86}$. |
| N.N.W.–S.S.E.. | 3. Depression.... | IV $A^{\zeta 88}$. IV $A^{\zeta 87}$, which is just at the S.E. corner of the disturbed rectangular area before described, is in the same line of direction. |
| N.N.W.–S.S.E.. | 4. Depression on a line of upheaval | IV $A^{\zeta 70}$, IV $A^{\zeta 74}$, IV $A^{\zeta 43}$, IV $A^{\zeta 93}$, IV $A^{\zeta 94}$, IV $A^{\zeta 92}$, IV $A^{\zeta 6}$, IV $A^{\zeta 45}$, IV $A^{\zeta 46}$, IV $A^{\zeta 29}$, IV $A^{\zeta 81}$. These objects, with the exception of the rill IV $A^{\zeta 81}$, are on the east side of the main line of fault N.N.W.–S.S.E. No. 5; the mountain IV $A^{\zeta 61}$ is just east of it. |
| N.N.W.–S.S.E.. | 5. Upheaval .... | IV $A^{\zeta 60}$, IV $A^{\zeta 36}$, IV $A^{\zeta 42}$, IV $A^{\zeta 90}$, IV $A^{\zeta 32}$, IV $A^{\zeta 44}$, IV $A^{\zeta 30}$. This is the main line of fault crossing the area. It appears as a portion of a lucid ray from Tycho in the full moon. It is noteworthy that these five lines of upheaval and depression are found in this area on the east of the main line of fault only, including it. |
| N. by W.–S. by E. | 1. Upheaval .... | IV $A^{\zeta 17}$, IV $A^{\zeta 55}$, IV $A^{\zeta 16}$. Forming the west border of Ptolemæus. |
| N. by W.–S. by E. | 2. Upheaval .... | IV $A^{\zeta 47}$. |
| N. by W.–S. by E. | 3. Upheaval .... | IV $A^{\zeta 48}$. |

*General Remarks.*—The most interesting feature resulting from this discussion, confined as it is in extent, is the almost rectangular area of *greatest* disturbance on IV $A^{\zeta}$ crossed by two main lines of fault which intersect each other in the point IV $A^{\zeta 36}$; one, W.N.W.–E.S.E. No. 2 (IV $A^{\zeta 67}$, IV $A^{\zeta 81}$), coincident with the north-east wall of Albategnius, having several craters opened on it, and running parallel with the S.S.W. and N.N.E. boundaries of the area; the other, N.N.W.–S.S.E. No. 5, which breaking through W.N.W.–E.S.E. No. 2 at the point of intersection, leads strongly to the conclusion that the line N.N.W.–S.S.E. No. 5 is the most recent, and this

ne of fault appears to be connected with Tycho. It does not appear at pre-nt that W.N.W.–E.S.E. No. 2 is connected with any centre or point of atbreak, unless it may be with IV $A^{\gamma 2}$, of which we may have to say more in reating of that area. Another disturbed area occurs on IV $A^{\alpha}$ between the ines W.N.W.–E.S.E. No. 2, N.W.–S.E. No. 1; it is bounded on the west by he line S. by W.–N. by E. No. 4. The lines of disturbance at right angles o W.N.W.–E.S.E. are the most numerous, nearly 30 per cent. of the whole on the two areas, equal to 17688·35 square miles English; and there is some reason to believe, as mentioned under IV $A^{\zeta 54}$, that the whole set may be in connexion with the easternmost of the ray-centres in the S.W. portion of the moon, but a more extensive examination is necessary before this can be decided. Arranging the whole of the directions according to a percentage scale, we have as under:—

| Directions. | Lines. | Percentage. |
|---|---|---|
| S.S.W.–N.N.E. .... | 14 | 29·17 |
| W.N.W.–E.S.E. .... | 9 | 18·75 |
| N.N.W.–S.S.E. .... | 7 | 14·59 |
| S. by W.–N. by E. .. | 4 | 8·33 |
| N. by W.–S. by E. .. | 4 | 8·33 |
| S.W.–N.E. ..... | 3 | 6·25 |
| W.S.W.–E.N.E. .... | 3 | 6·25 |
| N.W.–S.E. ..... | 3 | 6·25 |
| N.–S. ..... | 1 | 2·08 |

The following Table exhibits the proportion in each area:—

| Directions. | IV $A^{\alpha}$. | | IV $A^{\zeta}$. | |
|---|---|---|---|---|
| | Lines. | Percentage. | Line. | Percentage. |
| S. by W.–N. by E. .. | 4 | 25·00 | | |
| S.S.W.–N.N.E. .... | 5 | 31·25 | 9 | 28·125 |
| W.N.W.–E.S.E. .... | 2 | 12·50 | 7 | 21·875 |
| N.N.W.–S.S.E. .... | 2 | 12·50 | 5 | 15·625 |
| W.S.W.–E.N.E. .... | .. | .. | 3 | 9·375 |
| S.W.–N.E. ..... | .. | .. | 3 | 9·375 |
| N. by W.–S. by E. .. | 1 | 6·25 | 3 | 9·375 |
| N.W.–S.E. ..... | 2 | 12·50 | 1 | 3·25 |
| N.–S. ..... | .. | .. | 1 | 3·125 |

Area IV $A^{\alpha}$ = 8877·925 square miles English.

Area IV $A^{\zeta}$ = 8810·425 square miles English.

It is worthy of remark that the directions giving the greatest numbers are at right angles to each other. That which is evidently the main line of fault, extending both N.N.W. and S.S.E. beyond the areas IV $A^{\alpha}$ and IV $A^{\zeta}$ is accompanied with the next greatest number of parallel lines of upheaval and depression, but confined to the eastward of the main line of fault, while in the other directions the numbers are few.

The point between IV $A^{\zeta 69}$, IV $A^{\zeta 70}$, IV $A^{\zeta 36}$, and IV $A^{\zeta 74}$ appears to be a centre of disturbance, or point of upburst. There is one of a secondary character at IV $A^{\zeta 32}$, which is also a point of intersection of lines of upheaval and depression.

Postscript.—1867, April 12.

In order to avoid any *bias* in the production of the outline, or in drawing up the catalogue, I purposely abstained, except in a few special instances, from consulting either B. & M. or Lohrmann, so that the work, so far as it has proceeded, is perfectly independent of the labours of previous selenographers; but while the foregoing sheets were passing through the press, and *after* the areas IV $A^{\alpha}$ and IV $A^{\zeta}$ were engraved, I very carefully compared them with Lohrmann's sections (the reader can make his own comparison with B. & M., the corresponding portions of their Map being given in the Plate). As it is not unlikely that some of the notes may be of interest, I take this opportunity of adding them. A few have already been inserted.

IV $A^{\alpha}$.—2. Reaumur. Neither B. & M. nor Lohrmann give any objects on this plain.

7. The mountain-range on which this crater is opened is continued by Lohrmann towards his mountain 34, Sec. I. (IV $A^{\zeta\,37}$), where he gives an opening into the plain west of IV $A^{\zeta\,24}$ (Lohrmann's W. Sec. I). IV $A^{\alpha\,17}$, IV $A^{\zeta\,39}$ is in the direction of this mountain-chain, and it may probably be the *craterlet* which Lohrmann shows on or near its south end.

12, 13 are shown by Lohrmann as valleys *opening into* Hipparchus. In his 'Topographie der Sichtbaren Mondoberfläche,' Sec. I. p. 45, he says, "The valley between 32 (IV $A^{\alpha\,30}$) and 33 (IV $A^{\alpha\,28}$) unites the interior floor of Hipparchus with the plain of the Mare vaporum."

I have not met with an opening—certainly not with one that would easily strike the attention—in the line of cliffs forming the N.E. boundary of Hipparchus. If I have interpreted Lohrmann's language correctly, it would appear that he considered that the floor of *Hipparchus* and that of the *Mare vaporum* (*Sinus Medii*, B. & M.) were at the same level. Now in my observations of the region around IV $A^{\alpha\,4}$ I found it *depressed* below *Hipparchus*, the line of cliffs forming the partition. The only valley which I have given is IV $A^{\alpha\,32}$, south of IV $A^{\alpha\,10}$. 1867, April 11, I found an *opening* in IV $A^{\alpha\,13}$; the surface is, however, inclined towards IV $A^{\alpha\,11}$.

Query. Is IV $A^{\alpha\,12}$ *blocked* towards IV $A^{\alpha\,10}$, as shown by Lohrmann, by the mountain which appears to be the east side of the valley IV $A^{\alpha\,32}$?

20. The mountain on the west of the south portion (IV $A^{\alpha\,21}$) appears to be figured by Lohrmann at the mouth of the valley between 32 and 33 of his Sec. I., but he does not in the slightest degree indicate the depression to the east.

25. This appears to be the N.W. side of the valley which Lohrmann mentions and figures in Sec. I. 87.

32. This valley is shown by Lohrmann *with a mountain-range within it*. The interior mountain-range I have not seen. Lohrmann shows the S.W. mouth of the valley *open*, and *exactly* in the line of the valley IV $A^{\eta\,18}$.

43, 58. These formations are *partially* shown by Lohrmann with at least *two* additional mountain-chains; IV $A^{\alpha\,43}$ appears, according to Lohrmann, to stand in a valley; IV $A^{\alpha\,58}$ is ill figured.

47. This cleft is well shown by Lohrmann, as well as the dark colour on the surface which is very marked in the photograph.

53. Lohrmann, in his text, p. 55, speaks of this valley as connecting the

plain W. Sec. I. (IV $A^{\alpha 9}$, IV $A^{\zeta 24}$) with a plain east of Hipparchus. He gives four openings (valleys) in the mountainous border of this plain, viz. 88, 89, and 90 of Sec. I., and another, which do not by any means appear prominently in the photograph.

59. Lohrmann gives this as the N.E. extremity of a long mountain-range parallel with IV $A^{\alpha 43}$.

61. Lohrmann gives a short low mountain-range which lies in the direction of this ray; or it may be IV $A^{\alpha 63}$.

72. This "Fault," which under a suitable illumination is quite apparent, is not indicated by Lohrmann, neither are the marked *dislocations* of the border of Rhæticus shown.

75. The north portion of this valley, with apparently a low mountain-range separating it from IV $A^{\alpha 76}$, is shown by Lohrmann in Sec. I. 25. The valley IV $A^{\alpha 75}$ as it enters IV $A^{\alpha 12}$ has a darker tint in Lohrmann.

77. Lohrmann shows a plain here.

79, 81. Are these the two craterlets which Lohrmann places at the entrance of his valley, Sec. I. 87?

80. Lohrmann mentions (p. 55) and delineates in this neighbourhood (probably the lower part of the slope of IV $A^{\alpha 80}$) a valley, 87, Sect. I., 7 German miles (32·2 English miles) in length. This valley, with the individuality ascribed to it by Lohrmann, has not arrested my attention. I am nevertheless disposed to regard it as running between IV $A^{\alpha 80}$ and IV $A^{\alpha 52}$. Lohrmann also mentions and shows *two* craterlets at its entrance.

The following objects occur in Lohrmann's Section I., 15, 30, 68, 69, 70.

The following objects are not found in Lohrmann's Section I., 23, 38, 39, 40, 41, 46, 57, 60, 64, 65, ? 66, 71, 73, 74, 82, 83, 84.

IV $A^{\zeta}$.—25. This formation is alluded to, although not individually described, by Lohrmann under 28, Sec. I., p. 44. The N.E. boundary is exceedingly ill figured by Lohrmann, and 34, with its two mountain-peaks, IV $A^{\zeta 61}$ and IV $A^{\zeta 37}$, is placed too far to the east. The valley IV $A^{\zeta 85}$ between IV $A^{\zeta 61}$ and IV $A^{\zeta 37}$ is *blocked* on the S.S.E. by Lohrmann.

27. This valley is well shown by Lohrmann. In it, just N.W. of his mountain (IV $A^{\zeta 56}$, IV $A^{\zeta 57}$ shown as one), he has placed a craterlet, which I have not found, nor am I aware that it is mentioned in his text.

31. This mountain is shown in Sec. I. of Lohrmann, but the semi-crater IV $A^{\zeta 88}$ is absent.

32. This mountain appears to be the N.E. spur of Lohrmann's 20, Sec. I., the south part of which he places in the position of Schmidt's crater-rill 355. I have not detected his N.W. spur, unless it be IV $A^{\zeta 71}$, which is a difficult object. Lohrmann gives four craterlets on the east side of the N.E. spur. I have seen three of them, viz. IV $A^{\zeta 90}$, IV $A^{\zeta 91}$, and IV $A^{\zeta 92}$.

33, 68. Both given by Lohrmann on Sec. I. IV $A^{\zeta 33}$ between his 48 and 20, and IV $A^{\zeta 68}$ on his 20.

40. It is uncertain if Lohrmann has this craterlet; he indicates a very small depression of a similar nature not far from its locality.

42, 43. Both these craterlets are given by Lohrmann on his mountain 19, Sec. I. I have not yet met with this mountain.

47. Lohrmann shows IV $A^{\zeta 47}$ as *connected* with a range running towards

IV $A^{\zeta 1}$ (X of Sec. I.). This does not appear to be the case from the photograph. The whole of this portion of the map requires to be very carefully examined under good atmospheric circumstances *at the telescope*. I have a record 1864, July 24, of the valley 88, Sec. I. between the range above mentioned and a parallel one.

52. Shown by Lohrmann, *but not at all correctly*. It is quite *detached* in Sec. I. from the mountain 20, on the south edge of which it is evidently situated.

56, 57. Lohrmann gives these mountains as *one*, which he describes as the highest of the mountain-ranges near 28 of Sec. I.

58. Lohrmann, Sec. I. p. 44, classes 25, 26, and 27 together as apparently belonging to *low wall-mountains*; 26 I have not found; 27 I describe as an ancient and partly filled crater (IV $A^{\zeta 58}$) with a slightly depressed surface and 25 is the depression IV $A^{\alpha 76}$ in the valley IV $A^{\zeta 85}$.

59. Lohrmann shows at the extremity of the mountain-arm IV $A^{\zeta 60}$, which he extends further to the S.W., a craterlet; this is probably IV $A^{\zeta 59}$.

67, 82. Schmidt's crater-rills 354 and 355 are situated respectively upon the S.W. edges of Lohrmann's two mountains 19 and 20, Sec. I., which he places in the mountain-border of Albategnius. These mountains he *separates* in the line with IV $A^{\zeta 90}$, IV $A^{\zeta 91}$, and IV $A^{\zeta 92}$. IV $A^{\zeta 42}$, which he places on the south part of his mountain 19, is a little too far east as compared with mine; and IV $A^{\zeta 36}$, which he places incorrectly with regard to IV $A^{\zeta 42}$ (inasmuch as it is on the S.W. of IV $A^{\zeta 42}$), he throws a little too far to the east of the line IV $A^{\zeta 90}$, IV $A^{\zeta 91}$, IV $A^{\zeta 92}$. It is the crater IV $A^{\zeta 36}$ which separates the rills, and Lohrmann shows it with IV $A^{\zeta 7}$ *lower* than the mountain-border and on the floor of Albategnius. There is no point of upburst indicated by Lohrmann such as is evident on the photograph.

78. Given by Lohrmann opening into a plain at a higher level than the floor of Ptolemæus. On this plain Lohrmann places IV $A^{\zeta 55}$. This plain is entirely wanting in the photograph. 1866, Sept. 17, $8^h$ to $10^h$, I recorded the appearance of a plateau between IV $A^{\zeta 75}$ and IV $A^{\zeta 17}$, intermediate in level between the high N.E. border of Albategnius and the low floor of Ptolemæus, which I afterwards found was the summit of the mountain IV $A^{\zeta 17}$, and between it and the mountain IV $A^{\zeta 75}$ was the deep hollow IV $A^{\zeta 97}$, seen very distinctly on the 19th of Sept. 1866. I have not met with Lohrmann's plain. The deep hollow IV $A^{\zeta 97}$ is entirely wanting in Sec. I., in which the plain occupies the position of IV $A^{\zeta 23}$.

84. Lohrmann shows this valley as *blocked* by a portion of the border of Ptolemæus between his 16, Sec. I., and the plain west of Ptolemæus, *i. e.* between IV $A^{\zeta 16}$ and IV $A^{\zeta 23}$.

The following objects, some very imperfectly, are found in Lohrmann, Sec. I., 10, 17, 26, 29, 83, 87.

The following objects do not occur in Lohrmann, 30, 54, 79, 86, 88, 89.

### Addenda to Catalogue.

86. A craterlet north of IV $A^{\alpha 4}$; estimated 2″·0 mag. 0·12.

First seen 1867, April 11, with the Royal Society's achromatic 4¼-inch aperture, power 230. It is not in B. & M., nor in Lohrmann.

87. The low central range in Rhæticus, the south part.

88. The mountain-range on which IV $A^{\alpha 7}$ is opened. It is δ of B. & M. The dotted lines in areas IV $A^{\alpha}$ and IV $A^{\zeta}$ indicate the west foot of this mountain-range, the east requires to be determined.

IV $A^{\zeta}$.—103. A craterlet east of IV $A^{\zeta 113}$; estimated 2″·0, mag. 0·12. Not in Lohrmann, but shown by B. & M.

104. A mountain on the plain IV $A^{\zeta 24}$ shown very plainly by Lohrmann on Sec. I., and mentioned in his text (p. 55) as lying in 0° 30′ of west long. and 5° 40′ of south lat., direction north to south, estimated length 6″·33, breadth 3″. It is inserted from Lohrmann's sections, but does not appear on the photograph. 1864, July 24, I saw and sketched it. The instrument used was the Hartwell Equatoreal, power 118, the eyepiece being furnished with a diaphragm having a narrow slit, along which the object was allowed to pass, or kept in position by the clock motion.

105. A hill between the south end of IV $A^{\zeta 104}$ and IV $A^{\zeta 47}$; estimated diameter 1″·75.

106. A hill between the north end of IV $A^{\zeta 104}$ and IV $A^{\zeta 47}$; estimated diameter 1″·75.

These two hills which are not seen on the photograph, are from Lohrmann. They are on his Sec. I., and mentioned in his text, p. 55. I saw and sketched them 1864, July 24.

107. A slight elevation in and rather west of the centre of IV $A^{\zeta 1}$, seen with the Royal Society's achromatic, 4¼-inch aperture, power 230, 1867, March 15, $7^{h}$ $40^{m}$, G. M. T.

108. A bright spot on the north part of the mountain IV $A^{\zeta 61}$.

109. A bright spot on the north part of the mountain IV $A^{\zeta 37}$. Both spots were seen 1867, March 15, $7^{h}$ $45^{m}$, G. M. T., with the Royal Society's achromatic, 4¼-inch aperture, power 230.

110. A mountain between IV $A^{\zeta 37}$ and IV $A^{\zeta 47}$ in the east border of Hipparchus.

111. The south part of the mountain-range IV $A^{\alpha 88}$.

112. A craterlet near the south end of IV $A^{\alpha 88}$, IV $A^{\zeta 111}$; estimated 3″·5, mag. 0·21. Shown by Lohrmann, but not by B. & M.

113. A craterlet S.E. of IV $A^{\zeta 112}$; estimated 2″·0, mag. 0·12. Not in Lohrmann, but shown by B. & M.

114. A depression N.E. of the north end of IV $A^{\zeta 110}$; estimated length S.W.–N.E. 4″·0. Neither in B. & M., nor in Lohrmann.

IV $A^{\zeta 103}$ and IV $A^{\zeta 110}$ to IV $A^{\zeta 114}$, excepting IV $A^{\zeta 111}$, were first seen by the author, 1867, April 11, with the Royal Society's 4¼-inch aperture, power 230. The positions are confirmed by the photograph, although the objects are not sufficiently distinct in the photograph to be recognized independently of observation with the telescope.

### Lines of Upheaval and Depression.

The south border of IV $A^{\zeta 58}$ is in the prolongation of the line of upheaval IV $A^{\zeta}$, W.N.W.–E.S.E. No. 6.

IV $A^{\zeta}$ S.S.W.–N.N.E. No. 5.—IV $A^{\zeta 48}$ and IV $A^{\zeta 47}$ are in continuation of this line, which forms a gentle curve convex to E.S.E.

IV $A^{\zeta}$ N.N.W.–S.S.E. No. 5.—This well-marked "line of fault" from Tycho is continued across the area IV $A^{\alpha}$ west of IV $A^{\alpha\,10}$ and Rhæticus.

The careful study of the lines of upheaval and depression is particularly recommended to lunar observers as *full of promise*. It is not at all unlikely that several of the "Rays from Tycho" will be found to possess the character of lines of volcanic energy. It is an interesting fact that the two points of upburst, IV $A^{\zeta\,36}$ and IV $A^{\zeta\,32}$, on the "ray from Tycho" crossing the area IV $A^{\zeta}$ occur in localities where several lines of upheaval and depression intersect each other.

*Concluding Remarks.*

We would again call attention to the Note on p. 239, to the effect that the present Map is not intended to be perfect or complete; and we are the more anxious on this point, as various suggestions have been offered with the view of rendering it more efficient, with which we most cordially agree. At present the engraved portions of the Map are in *outline*, and will doubtless require *considerable modification*, as observers work at the subzones (see pp. 241, 242) which they may select. One suggestion, and a very important one, is, "that as the *craters* on the moon's surface are the leading objects, catching the eye *first*, and giving points of reference to the region under observation, it would greatly facilitate the work of observers if the craters were rendered more conspicuous in the engravings." The present imperfection of our knowledge of "detail" interferes materially with adopting any conventional mode of distinguishing one class of objects from another, further than as explained on p. 240; but as the Maps are intended for working-purposes, and are printed on paper that will bear *colouring*, we would strongly recommend that each observer should, before commencing his observations, tint with a suitable colour the craters in his pair of subzones; and if a few other conspicuous objects, as mountains, were desirable as points of reference, they might be tinted, but with a colour as much in contrast as possible. The portion of Beer and Mädler's map, referred to on p. 241, does not accompany this Report.

## Appendix IV.

Determination of the apparent Equator on De La Rue's Photograph, 1865, October $4^{d}\ 9^{h}\ 0^{m}\ 4^{s}$.

| Name. | X, Pho. | X, B. & M. | Diff. |
|---|---|---|---|
| S. | | | |
| Messier | ·035 | ·035 | ·000 |
| Theophilus | ·200 | ·196 | +·004 |
| Albategnius | ·190 | ·193 | −·003 |
| Dollond | ·173 | ·178 | −·005 |
| Herschel | ·096 | ·098 | −·002 |
| Gassendi | ·286 | ·291 | −·005 |
| N. | | | |
| Picard | ·253 | ·250 | +·003 |
| Dionysius | ·054 | ·051 | +·003 |
| Linné | ·470 | ·466 | +·004 |
| Arstillus | ·560 | ·556 | +·004 |
| Pico | ·718 | ·713 | +·005 |
| Kepler | ·147 | ·135 | +·012 |

Determination of the apparent First Meridian.

| Name. | Y, Pho. | Y, B. & M. | Diff. |
|---|---|---|---|
| W. | | | |
| Albategnius ..... | ·079 | ·068 | +·011 |
| Theophilus..... | ·451 | ·434 | +·017 |
| Messier ..... | ·754 | ·733 | +·021 |
| Dollond ..... | ·262 | ·242 | +·020 |
| Picard ..... | ·803 | ·782 | +·021 |
| Dionysius ..... | ·313 | ·294 | +·019 |
| Linné..... | ·191 | ·177 | +·014 |
| Aristillus ..... | ·023 | ·015 | +·008 |
| E. | | | |
| Gassendi..... | ·602 | ·609 | −·007 |
| Herschel ..... | ·028 | ·037 | −·009 |
| Kepler ..... | ·601 | ·606 | −·005 |
| Pico ..... | ·105 | ·112 | −·007 |

The values of the coordinates are expressed in parts of the moon's semi-diameter, which is equal to unity. See Report, 1865, p. 295.

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*Report of the Rainfall Committee, consisting of* J. Glaisher, *F.R.S.*, Lord Wrottesley, *F.R.S.*, Prof. Phillips, *F.R.S.*, Prof. Tyndall, *F.R.S.*, Dr. Lee, *F.R.S.*, J. F. Bateman, *F.R.S.*, R. W. Mylne, *F.R.S.*, Charles Brooke, *F.R.S.*, *and* G. J. Symons, *Secretary*.

It is satisfactory to state that in all branches of rainfall investigations steady progress has been maintained, and order, regularity, and accuracy more fully established than at any previous time. Mr. Symons's last Report to this Association in the volume just published, contained an epitomized history of rainfall investigations from 1677 to 1865, the present one deals principally with the progress made since the Meeting at Birmingham. The Rainfall Committee appointed at that Meeting having been fully impressed with the paramount importance of promptly collecting all the old rain records that are in any way accessible, directed that a circular should be sent to every newspaper in the United Kingdom; and as the circulars had to be modified for each journal, and there are upwards of 1400 newspapers regularly published, the preparation of these circulars was rather a tedious process, even to one pretty well used to voluminous work. They were, however, all ready at last, and posted simultaneously. It speaks volumes for the willingness of the press to help science, and for its disinterested public spirit, that these circulars (and troublesome ones to print too) were inserted by many hundred journals without a scruple or a word as to payment. The circulars were as follows:—

British Rainfall.

*To the Editor of the*

Sir,—I have to ask your readers' attention for a few moments to a request on the above subject, the importance of which in relation to engineering and drainage questions is well known. It is now some years since I began collecting returns of the fall of rain—with what success I will mention presently, but my main difficulty has been to find out the persons who keep such records, and one of the most obvious sources of assistance is the Public Press; I now, therefore, ask from each and every journal in the British Isles their all-powerful aid. When the collection was first organized in 1860, scarcely 200 persons were known to observe and record the rainfall; by steady per-

severance, and the aid of a portion of the press, the number has been raised until there are now more than 1200 places whence returns are regularly received. Still I know there are many more, probably hundreds, who have either never heard of the establishment of a central depôt to which copies of all rain records should be sent, or they have been too diffident to send them. It is of paramount importance to gather these, and make the Tables yet more complete. I therefore beg leave through your columns to ask every reader to think for a moment if he or she knows of any one who keeps, or has kept, a rain-gauge; or who has any tables of rainfall (or old weather journals) in their possession. And if they do know of such persons, I ask them on behalf of science, of my fellow-observers, and on my own behalf, to use every effort to secure their assistance, and to favour me with their names and addresses. We want old records, we want records for the present year, and from many parts of the country we want returns for the future, if a few persons will notify to me their willingness to assist, and to pay 10*s.* 6*d.* for the very cheap and simple gauge now supplied.

To prevent needless correspondence, I annex a list of the places in *Bedfordshire* whence returns have been already collected for the years mentioned in the last column, and shall be very glad of any additions or corrections. Other counties, or the complete list for the whole country, shall be sent to any one willing to make good use of it. I may add that an influential committee of the British Association has been appointed to superintend and assist in my investigations, and that they cordially support my present application.

I am, Sir, your obedient Servant,

136 Camden Road, London, N.W. G. J. Symons.

The Committée consists of J. Glaisher, Esq., F.R.S.; Lord Wrottesley, F.R.S.; Prof. Phillips, F.R.S.; Prof. Tyndall, F.R.S.; Dr. Lee, F.R.S.; J. F. Bateman, Esq., F.R.S.; R. W. Mylne, Esq., F.R.S., and myself.

Bedfordshire.

| Station. | Elevation. | Observer. | Period. |
|---|---|---|---|
| Ampthill | ... | W. S. Slinn, Esq. | C 1865- |
| Bedford (Britannia Farm) | ... | Mr. T. Bowick | C 1865- |
| † „ (Harper Street) | 112 | Dr. Barker | C 1851- |
| „ (Observatory) | ... | Admiral Smyth | 1831, 1833-38 |
| Cardington (Staff gauge) | 100 | Mr. M'Laren | C 1846- |
| „ (Obs. gauge) | 100 | „ | C 1848- |
| „ (36 ft. + ground) | 136 | „ | C 1848- |
| „ (Sharnbrook) | ... | R. S. Stedman, Esq. | |
| Potton (Sutton Park) | ... | Sir J. M. Burgoyne | C 1864- |
| Stotfold [Baldock] | 220 | W. Denne, Esq. | 1864- |
| Woburn (Apsley) | 460 | Rev. G. W. Mahon | C 1856- |

The practical results of the publication of upwards of a million copies of this circular were awaited with much interest. Many hundreds (if not thousands) of letters were received, but the majority of them referred either to observers with whom Mr. Symons was already in correspondence, or to old observations already collected. About 200 letters notified that the writers had recently procured rain-gauges, and would be happy to send the results in future; and about 100 only contained what was (and is) most required, namely, old observations not previously collected—some of these were very valuable records; but on the whole the result of the appeal was to confirm the belief that there are not now very many records in private hands of which copies are not already obtained and classified.

Taking, as we may, the total number of additional stations at 300, it does not seem expedient to give yet a list of them, but rather subsequently to issue a supplement to the list in the last Report, or perhaps a completed reprint.

*Extraction and Classification of published Records.*—We regret to say that absolutely nothing has been done in searching the Library of the British Museum during the past year. Records once *there* being safe, it has been judged more expedient to secure those from other quarters, where their safe custody is always uncertain; the observers die, and the records are too often destroyed.

*Examination of Rain-gauges.*—Ever since Mr. Symons's rainfall investigations were commenced, he has made it a principal aim to visit as many as possible of the gauges actually at work, and by conversation with the observers, and by examination of the accuracy of their gauges and the suitability of their position, to secure at once stronger personal interest in the work, and greater uniformity and accuracy in the mode of carrying it on. It is therefore with much pleasure that the details of 166 such visits are annexed to this Report, drawn up, it is hoped, in such a manner as to afford a good general idea of the position of the gauges, and absolute knowledge of the degree of accuracy of each gauge at different points of its scale. Without entering at present on a minute analysis of the results of these examinations, it may be affirmed that they are on the whole immensely beneficial. As a rule, the gauges are found to be in error less than two per cent.; and though now and then he comes upon gauges which are a disgrace to those who made them, these cases are altogether exceptional. A more frequent source of error is the proximity of trees and tall plants; it cannot be too strongly impressed on observers, that they *must* keep a clear open space round their gauges.

*Inclined and Tipping Funnelled Gauges.*—At the last Meeting of this Association it was suggested by Mr. Varley and Prof. Phillips that we should ascertain the indications of a gauge whose mouth instead of being horizontal should be inclined, and kept face to wind by a vane. We are happy to be able to announce that Mr. Chrimes of Rotherham has erected, and regularly observed, a most exhaustive set of instruments for the investigation of this question. They are erected on a piece of exposed high land in the suburbs of Rotherham, and the gauges are read daily and 5 monthly.

The instruments are—

1. A gauge similar to one employed many years ago by Prof. Phillips, having one horizontal and four vertical funnels, facing E., W., N., and S. Of course if the rain is absolutely vertical it will only enter the horizontal funnel; if coming absolutely horizontal, and from, say, due east, it will only enter the funnel facing east; if at any intermediate angle, it will partly fall into two or three funnels, each being provided with separate pipes and taps; the quantity caught by each is known, and the angle and point whence the rain fell can be easily calculated.

2 to 5. Four gauges revolving by vanes, and having their funnels tilted towards the wind at angles of 22½°, 45°, 67½°, and 90°.

6. A gauge similar to the above, except that the tilt of the gauge is *not* fixed, but, being supplied with levers, &c., varies with the pressure of the wind. In a dead calm the funnel is horizontal, and in a gale it will, it is hoped, be tilted to an angle of 70° or 80°. It should thus be always at right angles to the wind, and catch more than any other gauge in windy weather.

7. A Robinson's anemometer, to give the horizontal motion of the air.

8. A set of gauges at different elevations—10 feet, 15 feet, 20 feet, and 25 feet above the ground; two at each height, one for daily and one for monthly measurements. These, and also the above-mentioned gauges, are all 5 inches diameter.

The observations were submitted for discussion to Mr. Baxendell, F.R.A.S., who reports as follows:—

*Note on Mr. Chrimes's Rain-gauge Experiments, by Joseph Baxendell, Esq. F.R.A.S.*—Comparing the quantity of rain received by the horizontal mouth of the five-mouthed gauge with that received by the 90° inclined gauge, I find that the mean monthly angles of deviation from the vertical of falling rain were—

April .... 54° 45′ May .... 50° 22′ June .... 35° 15′

The mean derived from the entire series of observations (not the mean of the monthly means) is 42° 13′. This value is greater than I was prepared to expect, but is borne out by the results of the other gauges; thus, the greatest quantity of rain was, in every month, received by the 45° inclined gauge; and comparing the results of *all* the inclined gauges, we obtain the following monthly values:—

April .... 56° May ..... 53° June..... 37°

The mean daily movement of the wind on rainy days was 149 miles. Arranging the rainy days in two groups, the one including all the days when the movement of the wind was *above*, and the other all those when it was *below* the mean value, we find that with a mean daily movement of 103·8 miles, the rain fell at an angle of 33° 38′ from the perpendicular, and with a mean daily movement of 227·4 miles the angle was increased to 58° 21′.

The five-mouthed gauge was in use two months earlier than the series of inclined gauges, and the mean monthly horizontal direction of the rain deduced from its indications was as follows:—

| | |
|---|---|
| February ..... | S. 74° 11′ W. |
| March..... | S. 25 4 E. |
| April ..... | N. 57 29 E. |
| May ..... | N. 65 14 E. |
| June ..... | N. 46 36 E. |

If I understand the construction of the tipping-gauge aright, it ought to receive more rain than any of the other gauges, but the observations show that while in general it receives more than the horizontal and vertical gauges, it receives less than the gauges whose orifices are inclined at angles of 22½°, 45°, and 67½°. On days when the velocity of the wind is less than the average, the tipping-gauge receives less than either the 22½° or 45° inclined gauge, and more than any of the other gauges; but with the velocity of the wind above the average, it receives more than the horizontal gauge and less than any of the others. It appears therefore to be irregular in its action, and to require some modification before its results can be used with confidence in rainfall investigations.

Josh. Baxendell.

Cheetham Hill, Manchester, August 17, 1866.

P.S.—So far as I can see at present, Mr. Chrimes's experiments do not throw any fresh light on the question as to the cause of the differences in the amounts of rain received by gauges at different elevations.

*Influence of River Mists on the Amount of Rain collected.*—An observer of great practical experience once marked on his return "affected by a large pool adjacent to the gauge." Mr. Symons at once began speculating how much this could amount to; and it has also often been questioned by those who, from an elevation, have seen the mist hanging over the windings of a river, so marked and well defined that its course can be traced for miles. Is it to these mists, or to the percolation of the water through the river banks, that their luxuriant vegetation is to be ascribed? If to the mists,

ıould we not find the rainfall in the places they cover above that of neighouring stations? By the cooperation of the Thames Conservancy Commisoners and the observer at Weybridge Heath (W. F. Harrison, Esq.), three auges have been erected with a view of testing the point*. There was bviously some little difficulty in deciding on the best mode of fixing the auge in the middle of the river, yet where it should be safe from injury by he barges or mischievous people. Eventually it was fixed on the top of one of the guard piles protecting Shepperton Weir; Mr. Symons felt at the time that, elevated 6 ft. above the water, 150 ft. from either bank, the gauge would, from its exposed position, catch too little, less even than the ordinary fall at that height, because of the great exposure, still he did not then see any better arrangement. On receipt of the following report from Mr. Harrison we are inclined next year to try if we can have the gauge moored floating on the stream, with its mouth only a foot or so above it.

Rainfall Observations at three Stations at and near Weybridge, Surrey.

| | 1st Station (read daily). Bartropps, Weybridge Heath. Observer, W. F. Harrison, Esq. | | 2nd Station (read monthly). Rev. Dr. Spyers's, Weybridge Village. Observer, W. F. Harrison, Esq. | | 3rd Station (read monthly). Shepperton Weir. Observer, Mr. Thomas Vokins. | |
|---|---|---|---|---|---|---|
| Month of year, 1866. | Height of rim of gauge. Above Mean sea-level... 150·26 feet. Ground ..... 0·50 | | Height of rim of gauge. Above Mean sea-level ... 53·08 feet. Ground ..... 0·66 | | Height of rim of gauge. Above Mean sea-level ... 41·79 feet. Ground ..... 6·00 | |
| | | inches. | | inches. | | inches. |
| January ... | ..... | 3·7475 | ..... | 3·2650 | ..... | 2·350 |
| February | ..... | 4·4058 | ..... | 4·1150 | ..... | 2·945 |
| March ... | ..... | 1·6275 | ..... | 1·5900 | ..... | 1·265 |
| April ..... | ..... | 2·0950 | ..... | 2·0675 | ..... | 1·880 |
| May ..... | ..... | 1·5025 | ..... | 1·5975 | ..... | 1·205 |
| June ..... | ..... | 3·1400 | ..... | 2·9275 | ..... | 3·045 |
| July ..... | ..... | 1·0400 | ..... | 1·1525 | ..... | 1·135 |
| | Totals..... | 17·5583 | ..... | 16·7150 | ..... | 13·825 |

Remarks.

The fall at station 2 differs but slightly from that at station 1, but is in defect five times for twice that it is in excess.

The fall at station 3 is very remarkably in defect of that at station 1, and materially so of that at station 2, being only once in excess of either of the other stations respectively. I think the extraordinary discrepancy between the fall at station 3 and that at the other stations during January and February is to be accounted for by the high winds which accompanied the rain in those months, causing much drift and splashing at such an exposed station as No. 3. The observer at that station is very careful, and has, I think, recorded the fall accurately.

W. F. Harrison.

Bartropps, Weybridge Heath.

* Station No. 1 is on the northern slope of a rising ground, about a quarter of a mile E.S.E. of the Weybridge Station of the London and South-Western Railway; No. 2 is close to Weybridge Church, about one mile N.N.W. of Station No. 1, and nearly level with the river; No. 3, at Shepperton Weir, is half a mile N.N.W. of No. 2, and one mile and a half N.N.W. of No. 1.

With the double object of checking these experiments in
tions of the Thames valley, and also of ascertaining how s
errors incidental to a rain-gauge on board ship, a gauge wa
tesy of the Elder Brethren of the Trinity House, placed on
light-ship, and its indications have been checked against th
the land stations at Sheerness, Shoeburyness, and Rochford
again seems to be a less amount in mid-stream, but neither
ments have gone on long enough for generalization.

*First Approximation to Fluctuation of Rainfall, 1726 t*

In Mr. Symons's last annual Report he gave "a few particu
the rainfall of the last fifty years," and exhibited the small
diagrams accompanying this Report*; that investigation he e
was temporary only, and if he had consulted only his own
would have remained for a few years longer the solitary exam
question; his reason being that the importance of the question
variation of rainfall is such that temporary and partial inve
unworthy of it. On the other hand, no sooner were the previ
lished, than he was urged to give some approximations to the
vious years, to see if older records gave any indication of drou
those of the ten years ending with 1865—to see, in short, wha
discovered in this hitherto untrodden branch of inquiry. He
if he persisted in maintaining that this second series, like the
a partial discussion of the question, curiosity would be partly
there would be less occasion to hurry on the final work, he n
submits the results of the following process.

(1) Eight of the longest and most complete registers were se
being for periods of over fifty years, viz. —

| | |
|---|---|
| Southwick, near Oundle, Northamptonshire (George Lynne, Esq.) | 1726 to 1 |
| Lyndon, near Oakham, Rutland (T. Barker, Esq.) | 1737 to 1 |
| Chatsworth, Derbyshire | 1761 to 1 |
| Manchester, Lancashire (Dr. Dalton) | 1794 to 1 |
| Derby, Derby (Mr. Swanwick) | 1809 to 1 |
| Radcliffe Observatory, Oxford (the Radcliffe observers) | 1815 to 1 |
| Cobham Lodge, Surrey (Miss Molesworth) | 1825 to 1 |
| Mean of ten stations as given in last Report | 1815 to 1 |

(2) The mean of each set of observations having been taken,
each year was divided thereby, and thus its relation to the me
whole period was converted into a ratio independent of the amount

(3) These values being therefore strictly comparable, have been
in parallel columns, and in order to connect all together, and to r
to one uniform base, the means were taken of each overlapping pa
the corrections thereby deduced having been applied, the ratios w
reduced to the following bases:—Mean of 51 years at Oxford; me
years at the ten stations quoted in last Report; and mean of 41 y
Cobham Lodge.

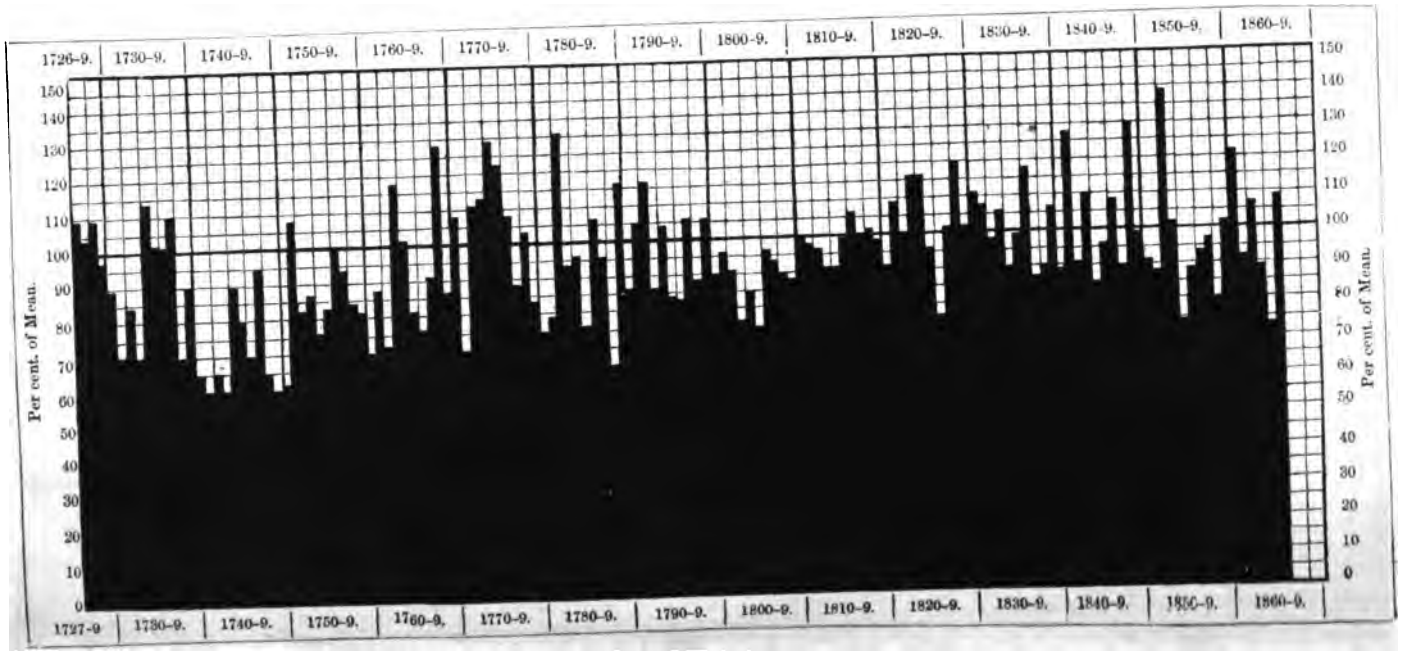
Of course identical results could not be expected from stations so
separated, now that we know how rarely is a year uniformly wet
throughout the kingdom; but Table III. showed results so similar,
felt no hesitation in constructing the large diagram, showing a "fi

* See Brit. Assoc. Rep. 1865, p. 202, for copy of small diagram.

[*To face page* 286.

| | | |

## RAINFALL FLUCTUATIONS FROM A.D. 1726 TO A.D. 1866.




[To face page 285.

roximation to fluctuation of rainfall, 1726 to 1865." Although unprepared or the extraordinary drought between 1730 and 1762, he is not at present nclined to impugn the accuracy of the returns*.

It will be seen that the drought of the years 1854 to 1864 is far exceeded n intensity by that at the commencement of the century, and still further by the extraordinary one previously mentioned as occurring between 1730 and 1762. It does not seem expedient to enlarge at any length on the many remarkable features of this diagram, but rather to leave the facts ready for all, and not be too precipitate in drawing conclusions.

One satisfactory point may be mentioned, viz., that in Mr. Symons's last Report the following remark was made:—"On carrying the investigation back to 1800 the fall then seems to have been *less* than it was about 1815." This will be seen to be amply confirmed by the present extended investigation.

TABLE IV.—Ratio in groups of ten years each from 1726 to 1865, from adopted mean of Table III. (Mean of fifty-one years, 1815 to 1865, at twelve stations = 100·0.)

| Period. | Ratio, 10 years. | 20 years. | Period. | Ratio, 10 years. | 20 years. |
|---|---|---|---|---|---|
| 1726 to 1735 .... | 94·6 | 86·7 | 1730–39 .... | 89·9 | 80·3 |
| 1736 „ 1745 .... | 78·7 | | 1740–49 .... | 70·6 | |
| 1746 „ 1755 .... | 78·6 | 83·5 | 1750–59 .... | 85·5 | 88·3 |
| 1756 „ 1765 .... | 88·3 | | 1760–69 .... | 91·1 | |
| 1766 „ 1775 .... | 103·6 | 98·4 | 1770–79 .... | 103·5 | 98·5 |
| 1776 „ 1785 .... | 93·2 | | 1780–89 .... | 93·5 | |
| 1786 „ 1795 .... | 96·6 | 93·2 | 1790–99 .... | 96·5 | 92·4 |
| 1796 „ 1805 .... | 89·7 | | 1800–09 .... | 88·2 | |
| 1806 „ 1815 .... | 94·6 | 99·3 | 1810–19 .... | 98·6 | 100·9 |
| 1816 „ 1825 .... | 103·9 | | 1820–29 .... | 103·2 | |
| 1826 „ 1835 .... | 101·3 | 100·8 | 1830–39 .... | 101·4 | 102·0 |
| 1836 „ 1845 .... | 100·2 | | 1840–49 .... | 102·6 | |
| 1846 „ 1855 .... | 100·6 | 98·5 | 1850–59 .... | 95·2 | |
| 1856 „ 1865 .... | 96·3 | | | | |

Table IV. is an abstract of the last column of Table III., which brings out very clearly the dry periods in the middle of the eighteenth, and at the beginning and in the middle of the nineteenth centuries.

One obvious use of Table III. may be mentioned, as it may not occur to every one, namely, that as these calculations are mainly based on stations in the midland counties, the probable fall at any place in that district, in any of the last 140 years, may be obtained by multiplying the adopted mean ratio from Table III. by the mean fall at any given place, as deduced from modern observations. For instance, the first year in the Table 1726 is set down 109; from modern observations we know that the mean fall in Northamptonshire is about 24 inches, then $1{\cdot}09 \times 24 = 26{\cdot}16$; the *observed* fall (26·70) was 2 per cent. *greater*. Fifty years later 1776 stands as 107; the fall in Rutland may also be taken at 24, then $1{\cdot}07 \times 24 = 25{\cdot}68$; the *observed* fall (27·84) was 9 per cent. *greater*. Another fifty years, and 1826 stands as 77; Manchester has a mean fall of 36 inches, then $\cdot 77 \times 36 = 27{\cdot}72$; the *observed* fall (24·91) was 8 per cent. *less*.

* Since these calculations have been finished, Mr. Symons has received from Dr. Barham of Truro a complete copy of the register kept at Plymouth from 1727 to 1752 by Dr. Huxham; the yearly totals and ratios are entered on Tables I. and II. so as to be available for comparison, but in different type, because they are not used in forming Table III. Their fluctuations agree very fairly with the adopted mean values in Table III.

Lastly, to take a short group of years, the fall at Ware, in Hertfordshire, may be taken at 25 inches, we then get the following results:—

| Year. | Ratio from Table III. | Computed fall. | Fall observed at Youngsbury. | Difference. |
|---|---|---|---|---|
| | | in. | in. | in. |
| 1787 ..... | 96 | 28·00 | 23·66 | −4·34 |
| 1788 ..... | 65 | 16·25 | 17·68 | +1·43 |
| 1789 ..... | 116 | 29·00 | 29·49 | +0·49 |
| 1790 ..... | 86 | 21·50 | 22·97 | +1·47 |
| 1791 ..... | 105 | 26·25 | 24·20 | −2·05 |
| | Mean..... | 24·20 | 23·60 | −0·60 |

This accordance is specially satisfactory for two reasons, it proves at once the safety of the plan suggested, and the reliability of these old observations.

## Rainfall 1864 and 1865.

Tables V., VI., and VII. continue the series of detailed rainfall tables commenced in 1860, and are arranged exactly as in previous years. The excessive drought of 1860, and its locality of greatest intensity, are shown very markedly by Tables V. and VI. Lengthened comment on the returns is undesirable, but it may be well to mention that the drought of 1864 prevailed only in England and Ireland, and that its greatest intensity was in the eastern counties, where many stations had less than 15 inches in the whole year. In July 1864 there was considerable drought, many English stations having less than a quarter of an inch; in October, on the contrary, there was an excessive rain in the south-east of Scotland amounting in Roxburgh to more than the fall in the previous nine months. September 1865 was the driest month that has occurred for some years: at 129 stations the fall was under a tenth of an inch, and at 48 no rain fell at all. October, however, was wet throughout the country; the ordinary fall in that month is 11 or 12 per cent. of the yearly total, in 1865 it was about 30 per cent.

Table V.—Average fall of Rain in 1864 and 1865, and difference between the two years: deduced from Table VI.

| Division. | | 1864. | 1865. | 1864–1865. |
|---|---|---|---|---|
| | | in. | in. | in. |
| England:— | I. Middlesex . . . . . | 17·280 | 28·612 | − 11·332 |
| „ | II. South-eastern Counties . . . . | 21·754 | 35·113 | − 13·359 |
| „ | III. South Midland Counties . . . . | 17·461 | 28·389 | − 10·928 |
| „ | IV. Eastern Counties . . . . . | 15·690 | 26·950 | − 11·260 |
| „ | V. South-western Counties . . . . | 26·859 | 41·088 | − 14·229 |
| „ | VI. West Midland Counties . . . . | 21·761 | 29·874 | − 8·113 |
| „ | VII. North Midland Counties . . . . | 20·746 | 25·861 | − 5·115 |
| „ | VIII. North-western Counties . . . . | 36·569 | 33·476 | + 3·093 |
| „ | IX. Yorkshire . . . . . | 25·624 | 27·940 | − 2·316 |
| „ | X. Northern Counties . . . . . | 44·925 | 41·957 | + 2·968 |
| Wales, &c. | XI. Monmouth, Wales, and the islands | 33·274 | 38·579 | − 5·305 |
| Scotland:— | XII. Southern Counties . . . . . | 45·963 | 42·988 | + 2·975 |
| „ | XIII. South-eastern Counties . . . . | 31·816 | 30·024 | + 1·792 |
| „ | XIV. South-western Counties . . . . | 41·227 | 35·932 | + 5·295 |
| „ | XV. West Midland Counties . . . . | 54·163 | 49·894 | + 4·269 |
| „ | XVI. East Midland Counties . . . . | 39·400 | 35·586 | + 3·814 |
| „ | XVII. North-eastern Counties . . . . | 31·889 | 29·781 | + 2·108 |
| „ | XVIII. North-western Counties . . . . | 44·446 | 36·394 | + 8·052 |
| „ | XIX. Northern Counties . . . . . | 32·782 | 27·194 | + 5·588 |
| Ireland:— | XX. Munster . . . . . | 36·840 | 44·753 | − 7·913 |
| „ | XXI. Leinster . . . . . | 29·967 | 32·334 | − 2·367 |
| „ | XXII. Connaught . . . . . | 40·373 | 42·190 | − 1·817 |
| „ | XXIII. Ulster . . . . . | 31·970 | 37·079 | − 5·109 |
| | Mean . . | 32·295 | 34·869 | − 2·574 |

TABLE VI.—Rainfall in 1864 and 1865, at selected stations.

## ENGLAND AND WALES.

| | 1864. in. | 1865. in. |
|---|---|---|
| **Div. I.—MIDDLESEX.** | | |
| Hammersmith | 16·69 | 25·89 |
| Camden Town | 17·02 | 29·44 |
| Hackney | 16·56 | 29·24 |
| Hampstead | 19·02 | 31·39 |
| Harrow | 18·95 | 29·00 |
| Lower Edmonton | 15·44 | 26·71 |
| **Div. II.—SOUTH-EASTERN COUNTIES.** | | |
| Dunsfold, Godalming | 17·85 | 30·32 |
| Deepdene, Dorking | 21·83 | 34·30 |
| Brockham, Betchworth | 20·53 | 31·89 |
| Cobham Lodge | 17·78 | 29·17 |
| Weybridge Heath | 16·39 | 26·99 |
| Bagshot | 18·44 | 31·37 |
| Kew Observatory | 16·95 | 26·45 |
| South Fields, Wandsworth | 17·75 | 29·23 |
| Dover | 23·04 | 38·03 |
| Horton Park, Hythe | 23·73 | 39·99 |
| Linton Park, Staplehurst | 21·25 | 35·18 |
| Tunbridge | 21·41 | 34·75 |
| River Hill, Sevenoaks | 18·42 | 29·69 |
| Acol, Margate | 15·84 | 29·80 |
| Welling, Bexley Heath | 18·08 | 30·13 |
| Aldwick, Bognor | 19·11 | 29·97 |
| Brighton | 22·85 | 35·13 |
| West Thorney | 22·88 | 31·51 |
| Chichester Museum | 23·25 | 35·68 |
| Bleak House, Hastings | 20·79 | 30·88 |
| Dale Park, Arundel | 20·71 | 42·26 |
| Battle | 28·30 | 39·60 |
| Chilgrove, Chichester | 24·67 | 38·45 |
| Hurstpierpoint | 23·39 | 36·36 |
| Petworth Rectory | 23·02 | 38·83 |
| Uckfield | 23·48 | 38·97 |
| Ventnor, Isle of Wight | 21·87 | 32·73 |
| Ryde, „ | 23·87 | 39·20 |
| Osborne, „ | 22·67 | 34·96 |
| Fareham | 24·75 | 39·11 |
| Southampton Ordnance Survey Office | 25·26 | 42·71 |
| Selborne, The Wakes | 23·71 | 38·18 |
| Liss, Petersfield | 25·22 | 42·81 |
| Aldershot | 18·61 | 29·62 |
| Sandhurst, Roy. Mil. Coll. | 15·38 | 24·37 |
| Long Wittenham | 13·31 | 30·35 |
| **Div. III.—SOUTH MIDLAND COUNTIES.** | | |
| Watford House | 18·40 | 29·59 |
| Berkhampstead | 19·82 | 31·70 |
| Royston | 16·67 | 29·33 |
| Hitchin | 17·16 | 30·26 |
| Radcliffe Obs., Oxford | 18·26 | 28·53 |
| Banbury | 20·22 | 28·29 |
| Althorpe | 17·21 | 25·50 |
| Wellingborough | 16·88 | 30·66 |
| Bedford | 15·73 | 24·78 |
| Wisbeach Observatory | 15·41 | 26·52 |
| Mid Level Sluice | 16·31 | 27·12 |
| **Div. IV.—EASTERN COUNTIES.** | | |
| Epping | 14·80 | 26·94 |
| Dorwards Hall, Witham | 15·40 | 24·99 |
| Dunmow | 14·98 | 27·00 |
| Bocking, Braintree | 16·94 | 27·04 |
| Ashdon, Linton | 15·98 | 25·40 |
| Grundisburgh | 16·25 | 28·85 |
| Culford, Bury St. Edmunds | 16·44 | 28·31 |
| Diss | 15·35 | 28·44 |
| Norwich | 17·79 | 26·51 |
| Egmere, Fakenham | 14·16 | 26·29 |
| Holkham | 14·50 | 26·68 |
| **Div. V.—SOUTH-WESTERN COUNTIES.** | | |
| Baverstock | 21·40 | 31·10 |
| Marlborough | 21·29 | 32·80 |
| Castle House, Calne | 20·17 | 29·92 |
| Encombe, Wareham | 21·16 | 37·40 |
| Little Bridy | 27·14 | 45·12 |
| Bridport | 22·07 | 40·31 |
| Saltram Gardens | 28·22 | 45·49 |
| Torhill, Ivybridge | 32·14 | 49·51 |
| Goodamoor, Plympton | 38·29 | 58·00 |
| Highwick, Newton Bushel | 25·40 | 46·68 |
| Westbrook, Teignmouth | 22·06 | 42·03 |
| Dawlish | 20·67 | 38·84 |
| Broadhembury | 25·37 | 37·15 |
| Cove, Tiverton | 28·48 | 44·50 |
| Castle Hill, South Molton | 33·55 | 46·49 |
| Great Torrington | 30·88 | 40·36 |
| Barnstaple | 26·43 | 39·36 |
| Helstone | 28·56 | 44·74 |
| Penzance | 29·83 | 47·58 |
| Tehidy Park, Redruth | 29·27 | 38·97 |
| Royal Institution, Truro | 32·14 | 48·26 |
| Bodmin | 37·13 | 48·98 |
| Treharrock House, Wadebridge | 30·24 | 41·53 |
| Rosecarrock, Port Isaac | 30·21 | 38·22 |
| Taunton | 21·00 | 33·62 |
| Long Sutton, Langport | 22·51 | 31·57 |
| Sherborne Reservoir | 28·49 | 41·96 |
| Batheaston | 17.96 | 29·96 |
| **Div. VI.—WEST MIDLAND COUNTIES.** | | |
| Park Row, Bristol | 21·93 | 33·82 |
| Clifton | 22·75 | 36·50 |
| Cirencester | 24·68 | 35·82 |
| The Spa, Gloucester | 17·11 | 21·81 |
| Haughton Hall, Shiffnal | 17·23 | 23·25 |
| Whitchurch | 22·03 | 25·24 |
| Hengoed, Oswestry | 27·29 | 38·34 |
| Northwick Park | 23·08 | 30·35 |
| West Malvern | 22·36 | 27·82 |
| Worcester (Lark Hill) | 20·39 | 28·04 |
| Orleton | 21·79 | 29·88 |
| Rugby | 16·39 | 25·94 |
| Edgbaston, Birmingham | 24·11 | 31·56 |
| Birmingham | 23·51 | 29·27 |

TABLE VI. (*continued*).

| Div. VII.—North Midland Counties. | 1864. in. | 1865. in. |
|---|---|---|
| Wigston | 17·60 | 26·80 |
| Thornton | 19·54 | 25·82 |
| Belvoir Castle | 16·34 | 25·22 |
| Greatford Hall, Stamford | 15·11 | 21·75 |
| Boston | 15·23 | 25·79 |
| Lincoln | 16·99 | 20·82 |
| Market Rasen | 14·67 | 23·32 |
| Gainsborough | 18·10 | 24·49 |
| Brigg | 19·60 | 25·17 |
| Grimsby | 15·37 | 21·84 |
| New Holland | 17·23 | 22·76 |
| Welbeck | 22·60 | 24·51 |
| East Retford | 24·10 | 23·74 |
| Derby | 21·74 | 24·46 |
| Chesterfield | 21·34 | 27·09 |
| Comb's Moss | 42·18 | 42·03 |
| Chapel-en-le-Frith | 34·94 | 34·03 |
| **Div. VIII.—North-Western Counties.** | | |
| Macclesfield | 30·20 | 27·19 |
| Quarry Bank | 26·33 | 26·93 |
| Manchester | 30·64 | 28·39 |
| Waterhouses | 29·99 | 27·53 |
| Bolton-le-Moors | 42·74 | 37·51 |
| Rufford, Ormskirk | 29·14 | 27·85 |
| Standish | 34·79 | 33·48 |
| Howick, Preston | 34·41 | 31·55 |
| South Shore, Blackpool | 28·80 | 26·55 |
| Stonyhurst | 41·80 | 40·59 |
| Caton | 41·93 | 34·36 |
| Holker, Cartmel | 43·56 | 38·35 |
| Wray Castle, Windermere | 61·06 | 54·91 |
| **Div. IX.—Yorkshire.** | | |
| Broomhall Park, Sheffield | 24·36 | 28·69 |
| Redmires, " | 31·88 | 32·47 |
| Tickhill | 19·36 | 25·26 |
| West Melton | 19·08 | 20·04 |
| Penistone | 24·80 | 26·73 |
| Saddleworth | 34·75 | 33·05 |
| Longwood, Huddersfield | 24·39 | 26·08 |
| Wakefield | 22·59 | 21·71 |
| Well Head, Halifax | 23·64 | 27·96 |
| Ovendon Moor " | 38·70 | 35·00 |
| Manor-road, Leeds. | 17·04 | 25·78 |
| Eccup, " | 18·95 | 22·66 |
| Boston Spa | 23·75 | 26·54 |
| York | 21·13 | 23·19 |
| Harrogate | 26·48 | 27·70 |
| Settle | 32·60 | 35·38 |
| Arncliffe | 45·78 | 47·26 |
| Beverley Road, Hull | 18·27 | 23·80 |
| Holme-on-Spalding-Moor | 21·14 | 25·16 |
| Malton | 22·85 | 23·32 |
| Beadlam Grange | 29·09 | 28·55 |
| Ganton, Scarborough | 23·10 | 28·35 |
| **Div. X.—Northern Counties.** | | |
| Darlington | 22·11 | 27·05 |
| Stubb House, Winston | 24·26 | 26·73 |
| Sunderland | 23·76 | 26·06 |
| Allenheads | 43·24 | 44·43 |
| Bywell | 28·77 | 29·82 |
| Wylam | 27·57 | 29·67 |

| Div. X.—Northern Counties (*continued*). | 1864. in | 1865. in. |
|---|---|---|
| North Shields | 26·77 | 26·90 |
| Deadwater | 42·80 | 39·[illegible] |
| Park End, Hexham | 29·02 | 29·[illegible] |
| Roddam | 35·88 | 31·72 |
| Lilburn Tower | 32·97 | 30·35 |
| Stonethwaite | 100·76 | 84·13 |
| Seathwaite | 134·67 | 117·49 |
| Whinfell Hall, Cockermouth | 50·49 | 44·25 |
| Keswick | 52·68 | 49·[illegible] |
| Cockermouth | 42·33 | 37·79 |
| Mire House, Bassenthwaite | 46·42 | 42·62 |
| Silloth | 33·57 | 28·74 |
| Scaleby | 27·27 | 28·85 |
| Kendal | 47·57 | 42·67 |
| Lesketh How | 74·09 | 65·80 |
| The How, Troutbeck | 75·74 | 64·05 |
| Edenhall, Penrith | 28·61 | 28·99 |
| Appleby | 28·85 | 30·26 |
| **Div. XI.—Monmouth, Wales, and The Islands.** | | |
| Abercarne | 40·45 | 45·75 |
| Blaina | 40·12 | 46·07 |
| Abergavenny | 27·18 | 35·76 |
| Swansea | 24·74 | 33·05 |
| Ystalyfera | 44·94 | 61·69 |
| Carmarthen | 38·89 | 50·47 |
| Rhydwen | 38·98 | 43·33 |
| Pembroke Dock | 36·91 | 42·69 |
| Haverfordwest | 40·06 | 50·77 |
| Lampeter | 32·58 | 42·39 |
| Frongoch | 37·20 | 43·74 |
| Pen-y-maes | 23·28 | 30·99 |
| Rhayader, Cefnfaes | 37·02 | 41·48 |
| Hawarden | 21·67 | 21·96 |
| Maes-y-dre | 21·19 | 21·22 |
| Llandudno | 25·35 | 28·11 |
| Talgarth Hall | 53·01 | 43·32 |
| Brithdin, Dolgelly | 41·23 | 57·59 |
| Bangor | 36·69 | 33·94 |
| Llanfairfechan | 31·39 | 33·80 |
| *Isle of Man.* | | |
| Calf of Man | 25·07 | 22·29 |
| Douglas | 37·60 | 33·80 |
| Point of Ayr | 28·12 | 27·15 |
| *Guernsey.* | | |
| Guernsey | 32·66 | 43·35 |
| Millbrook, Jersey | 25·95 | 39·04 |
| Gorey " | 22·85 | 29·37 |
| Alderney | 20·56 | 30·57 |
| **SCOTLAND.** | | |
| **Div. XII.—Southern Counties.** | | |
| Stranraer, South Cairn. | 42·45 | 41·30 |
| Little Ross | 26·59 | 25·24 |
| Slogarie, Castle Douglas | 65·95 | 57·78 |
| Cargen | 40·12 | 41·19 |
| Drumlanrigg | 42·00 | 39·55 |
| Wanlockhead | 58·67 | 52·87 |

TABLE VI. (*continued*).

| | 1864. in. | 1865. in. |
|---|---|---|
| **Div. XIII.—South-Eastern Counties.** | | |
| Selkirk, Bowhill | 28·82 | 28·69 |
| N. Esk Reser, Penicuick | 35·98 | 36·70 |
| Berwick | 31·75 | 28·80 |
| Yester | 34·15 | 36·10 |
| East Linton | 29·92 | 23·87 |
| Glencorse | 35·80 | 34·60 |
| Inveresk | 30·02 | 27·78 |
| Charlotte Square, Edinburgh | 28·09 | 23·65 |
| **Div. XIV.—South-Western Counties.** | | |
| Newmains, Castle Douglas | 44·88 | 36·42 |
| Auchinraith | 27·35 | 24·28 |
| Glasgow Observatory | 37·15 | 35·37 |
| Baillieston | 41·71 | 38·04 |
| Hillend House, Shotts | 32·10 | 24·18 |
| Girvan | 43·35 | 41·66 |
| Auchendrane House, Ayr | 36·81 | 31·06 |
| Mansfield, Largs | 42·80 | 39·80 |
| Nither Place, Mearns | 51·75 | 38·38 |
| Paisley, Stanely Reservoir | 39·80 | 36·63 |
| Greenock | 55·80 | 49·43 |
| **Div. XV.—West Midland Counties.** | | |
| Balloch Castle | 49·87 | 45·20 |
| Arddarrock, Loch Long | 70·60 | 60·79 |
| Stirling, Polmaise Gardens | 36·00 | 32·60 |
| Pladda | 23·53 | 26·95 |
| Devaar, Campbeltown | 38·53 | 40·61 |
| Rhinns of Islay | 27·17 | 34·35 |
| M'Arthur's Head | 60·40 | 54·40 |
| Tarbert, Stonefield | 56·20 | 55·70 |
| Hafton, Dunoon | 68·51 | 56·42 |
| Otter House | 56·14 | 47·84 |
| Kilmory, Lochgilphead | 53·50 | 55·20 |
| Fladda | 62·30 | 68·20 |
| Inverary Castle | 47·50 | 40·10 |
| Oban | 62·43 | 54·25 |
| Lismore | 52·12 | 40·11 |
| Hynish, Tiree | 78·42 | 76·70 |
| Loch Eil Corran | 85·55 | 67·90 |
| Ardnamurchan | 46·17 | 40·78 |
| **Div. XVI.—East Midland Counties.** | | |
| Dollar | 36·62 | 36·20 |
| Loch Leven Sluice | 36·10 | 34·10 |
| Leven, Nookton | 29·75 | 25·77 |
| Dunblane, Kippenross | 38·20 | 32·35 |
| Deanston | 41·90 | 33·75 |
| Loch Katrine | 71·20 | 61·70 |
| Auchterarder House | 33·51 | 32·70 |
| Stronvar, Loch Earnhead | 71·67 | 62·11 |
| Trinity Gask | 37·20 | 30·55 |
| Scone Palace | 28·70 | 28·79 |
| Stanley | 28·60 | 27·46 |
| Dundee | 33·97 | 30·59 |
| Arbroath | 34·20 | 27·88 |
| Montrose | 29·99 | 34·26 |
| **Div. XVII.—North-Eastern Counties.** | | |
| Brechin, The Burn | 36·30 | 34·70 |
| Bogmuir | 33·30 | 30·20 |
| Banchory House | 26·10 | 32·40 |
| Braemar | 32·50 | 29·72 |
| Aberdeen | 27·95 | 27·68 |
| **Div. XVII.—North-Eastern Counties (*continued*).** | | |
| Castle Newe | 36·48 | 33·35 |
| Tillydesk, Ellon | 32·96 | 27·09 |
| Elgin Institution | 29·52 | 23·11 |
| **Div. XVIII.—North-Western Counties.** | | |
| Inverinate House, Loch Alsh | 62·30 | 56·73 |
| Cromarty | 23·32 | 19·51 |
| Ardross Castle, Alness | 35·34 | 29·68 |
| Oronsay | 92·86 | 46·98 |
| Raasay | 69·95 | 57·25 |
| Barrahead | 36·77 | 35·44 |
| S. Uist, Ushenish | 39·95 | 39·66 |
| Island Glass | 17·51 | 17·93 |
| Urquhart, Corrimony | 41·70 | 35·80 |
| Culloden | 24·76 | 24·96 |
| **Div. XIX.—Northern Counties.** | | |
| Dunrobin Castle | 28·16 | 21·06 |
| House of Tongue | 43·70 | 28·90 |
| Cape Wrath | 38·19 | 32·80 |
| Nosshead | 27·23 | 15·09 |
| Holburnhead | 18·14 | 24·91 |
| Pentland, Skerries | 31·94 | 26·05 |
| Balfour Castle | 30·75 | 25·45 |
| Sandwick | 33·28 | 34·21 |
| Sumburghead | 23·90 | 20·47 |
| Bressay | 43·00 | 32·10 |
| East Yell | 42·31 | 38·09 |
| **IRELAND.** | | |
| **Div. XX.—Munster.** | | |
| Cork | 34·61 | 43·01 |
| Valentia | 47·62 | 59·09 |
| Waterford | 34·46 | 41·02 |
| Portlaw | 40·27 | 47·25 |
| Killaloe | 35·64 | 46·04 |
| Ennis | 28·44 | 32·11 |
| **Div. XXI.—Leinster.** | | |
| Kilkenny | 35·18 | 30·43 |
| Portarlington | 42·45 | 43·84 |
| Birr Castle, Parsonstown | 27·04 | 31·90 |
| Tullamore | 23·98 | 26·92 |
| Bray, Fassaroe | 31·66 | 42·21 |
| Black Rock | 25·73 | 29·80 |
| Dublin | 29·75 | 29·23 |
| Glasnevin | 23·95 | 24·34 |
| **Div. XXII.—Connaught.** | | |
| Gort, Cregg Park | 33·89 | 38·43 |
| Queen's College, Galway | 58·07 | 48·90 |
| Doo Castle, Bunninadden | 31·89 | 39·62 |
| Hazlewood, Sligo | 37·64 | 41·81 |
| **Div. XXIII.—Ulster.** | | |
| Red Hills, Belturbet | 27·07 | 36·92 |
| Florence Court | 29·43 | 43·15 |
| Armagh Observatory | 34·82 | 37·93 |
| Miltown, Banbridge | 25·10 | 29·21 |
| Waringstown | 25·44 | 28·62 |
| Antrim | 29·74 | 29·41 |
| Moneydig, Garvagh | 31·76 | 37·86 |
| Londonderry | 35·03 | 39·24 |
| Leckpatrick, Strabane | 34·99 | 37·99 |
| Letterkenny | 46·32 | 50·46 |

## TABLE VII.—TABLES OF MONTHLY RAI
## ENGLAND AND WALES.

### Division I.—Middlesex.

#### Middlesex.

| Height of Rain-gauge above Ground ..... Sea-level..... | Hammersmith. 1 ft. 0 in. 12 ft. | | Camden Town. 0 ft. 4 in. 100 ft. | | Hackney. 0 ft. 6 in. 40 ft. | | Hampstead. 1 ft. 0 in. 360 ft. | | Harrow. 1 ft. 2 in. 354 ft. | | Lower Edmonton. 0 ft. 9 in. ..... | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| January ..... | 1·00 | 2·98 | 1·07 | 3·63 | 1·06 | 3·27 | 1·25 | 3·50 | 1·24 | 2·41 | ·87 | 2·5 |
| February ... | ·84 | 2·18 | ·76 | 2·27 | ·80 | 2·04 | ·94 | 2·63 | ·92 | 2·72 | ·86 | 2·2 |
| March ..... | 2·42 | 1·17 | 2·61 | 1·09 | 2·54 | 1·08 | 2·85 | 1·09 | 2·15 | 1·01 | 2·27 | 1·1 |
| April ..... | ·76 | ·22 | ·92 | ·37 | 1·18 | ·46 | ·86 | ·33 | 1·30 | ·53 | ·78 | ·3 |
| May ..... | 1·51 | 3·44 | 1·54 | 3·40 | 1·62 | 3·67 | 1·74 | 3·13 | 1·94 | 3·00 | 1·43 | 2·7 |
| June ..... | 2·09 | ·78 | 1·68 | 1·71 | 1·44 | 1·91 | 2·25 | 1·71 | 2·09 | 1·96 | 1·83 | 1·6 |
| July ..... | ·21 | 1·38 | ·61 | 1·91 | ·50 | 2·21 | ·59 | 2·30 | ·51 | 2·44 | ·41 | 2·3 |
| August ..... | 1·22 | 4·46 | 1·30 | 4·97 | 1·22 | 4·72 | 1·18 | 5·77 | 1·19 | 4·75 | ·87 | 4·3 |
| September ... | 2·75 | ·53 | 2·53 | ·56 | 2·30 | ·30 | 3·19 | ·62 | 2·98 | ·36 | 2·24 | ·2 |
| October ..... | 1·19 | 5·60 | 1·14 | 6·20 | 1·04 | 6·27 | 1·32 | 6·76 | 1·82 | 6·22 | 1·04 | 6·0 |
| November ... | 2·27 | 2·39 | 2·18 | 1·97 | 2·26 | 2·25 | 2·09 | 2·32 | 2·10 | 2·55 | 2·12 | 2·0 |
| December ... | ·43 | ·76 | ·68 | 1·36 | ·60 | 1·06 | ·76 | 1·23 | ·71 | 1·05 | ·72 | 1·1 |
| Totals ..... | 16·69 | 25·89 | 17·02 | 29·44 | 16·56 | 29·24 | 19·02 | 31·39 | 18·95 | 29·00 | 15·44 | 26·7 |

### Division II.—South-Eastern Counties (*continued*).

| Surrey (*continued*). | | Kent. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Height of Rain-gauge above Ground ..... Sea-level..... | Wandsworth S. Fields. 1 ft. 0 in. ..... | Dover. 2 ft 2 in. 16 ft. | | Horton Park, Hythe. 1 ft. 6 in. 350 ft. | | Linton Park, Staplehurst. 0 ft. 6 in. 300 ft. | | Tunbridge. 1 ft. 0 in. 125 ft. | | River Hill Sevenoaks. 9 ft. 0 in. 520 ft. | |
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| January ..... | ·87 | 3·30 | ·68 | 5·49 | 1·11 | 4·15 | ·77 | 4·48 | ·74 | 3·80 | ·76 | 3·6 |
| February ... | ·85 | 1·88 | 1·97 | 2·61 | 2·27 | 3·05 | 1·36 | 2·49 | 1·16 | 2·13 | ·97 | 2·0 |
| March ..... | 2·70 | ·95 | 2·66 | 2·27 | 2·57 | 3·63 | 3·06 | 2·14 | 3·42 | 1·91 | 3·11 | 1·4 |
| April ..... | 1·00 | ·27 | ·61 | ·24 | ·46 | ·36 | ·59 | ·38 | ·88 | ·36 | ·82 | ·3 |
| May ..... | 2·00 | 3·00 | 2·18 | 2·53 | 2·15 | 3·42 | 2·35 | 2·89 | 1·76 | 3·64 | 1·64 | 3·4 |
| June ..... | 1·35 | 2·25 | 1·91 | 1·46 | 2·48 | 1·03 | 1·24 | 1·17 | 1·22 | 1·19 | 1·15 | 1·1 |
| July ..... | ·55 | 2·60 | ·32 | 4·35 | ·71 | 3·55 | ·63 | 3·48 | ·51 | 4·48 | ·56 | 3·9 |
| August ..... | 2·58 | 4·38 | 1·69 | 3·76 | 1·59 | 3·97 | 1·63 | 5·26 | 1·18 | 4·84 | 1·26 | 4·1 |
| September ... | 1·57 | ·57 | 2·44 | ·15 | 2·96 | ·54 | 2·51 | ·08 | 3·21 | ·02 | 2·51 | ·0 |
| ..... | 1·25 | 6·13 | 1·62 | 9·23 | 1·22 | 9·79 | 1·47 | 8·14 | 1·63 | 7·86 | ·85 | 6·9 |
| ... | 2·65 | 2·55 | 5·96 | 4·58 | 5·29 | 4·88 | 4·50 | 2·74 | 4·65 | 2·78 | 3·78 | 2·1 |
| ... | ·38 | 1·35 | 1·00 | 1·36 | ·92 | 1·62 | 1·14 | 1·93 | 1·05 | 1·74 | 1·01 | ·9 |
| .... | 17·75 | 29·23 | 23·04 | 38·03 | 23·73 | 39·99 | 21·25 | 35·18 | 21·41 | 34·75 | 18·42 | 29·9 |

# L IN THE BRITISH ISLES.

## ENGLAND AND WALES.

### Division II.—South-Eastern Counties.

| | | Surrey. | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| unsfold, dalming. | | Deepdene, Dorking. | | Brockham, Betchworth. | | Cobham. | | Weybridge Heath. | | Bagshot. | | Kew Observatory. | |
| ft. 6 in. ..... | | 2 ft. 9 in. ..... | | 0 ft. 6 in. 130 ft. | | 0 ft. 7 in. 100 ft. | | 0 ft. 6 in. 150 ft. | | 3 ft. 0 in. 200 ft. | | 1 ft. 3 in. 19 ft. | |
| 64. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| ·25 | 2·92 | 1·13 | 3·85 | ·68 | 3·41 | ·83 | 2·73 | ·71 | 2·04 | ·85 | 2·33 | ·96 | 3·10 |
| ·05 | 1·70 | ·93 | 2·80 | ·98 | 2·07 | ·85 | 2·00 | ·88 | 2·02 | ·97 | 2·92 | ·73 | 1·95 |
| ·90 | ·80 | 3·62 | 1·28 | 3·39 | 1·55 | 3·14 | ·84 | 2·67 | ·73 | 3·05 | 1·06 | 2·63 | ·81 |
| 1·35 | ·40 | 1·00 | ·25 | ·79 | ·33 | ·95 | ·39 | 1·04 | ·43 | 1·77 | ·54 | ·86 | ·45 |
| 1·62 | 1·90 | 1·68 | 2·45 | 2·13 | 2·87 | 1·34 | 4·62 | 1·59 | 2·67 | 1·47 | 2·42 | 1·59 | 3·27 |
| 1·25 | 2·40 | 1·55 | 1·45 | 1·04 | 2·28 | 1·19 | 1·76 | 1·00 | 2·54 | ·91 | 2·84 | 2·06 | 1·58 |
| ·35 | 2·35 | ·47 | 3·05 | ·95 | 2·68 | ·45 | 2·15 | ·29 | 2·17 | ·46 | 2·23 | ·67 | 1·82 |
| ·70 | 4·25 | ·88 | 5·12 | ·96 | 4·45 | 1·25 | 4·53 | 1·06 | 4·28 | 1·00 | 4·43 | 1·25 | 4·34 |
| 2·85 | ·10 | 3·82 | ·15 | 3·59 | ·15 | 2·83 | ·19 | 2·83 | ·37 | 2·79 | ·53 | 2·50 | ·47 |
| 1·35 | 7·70 | 1·78 | 8·58 | 1·89 | 6·79 | 1·73 | 6·47 | 1·32 | 6·37 | 1·84 | 6·83 | 1·28 | 6·15 |
| 1·75 | 3·60 | 3·80 | 4·67 | 3·51 | 3·67 | 2·50 | 2·42 | 2·63 | 2·12 | 2·86 | 3·26 | 1·93 | 1·86 |
| ·45 | 2·20 | 1·17 | ·65 | ·62 | 1·64 | ·72 | 1·07 | ·37 | 1·25 | ·47 | 1·98 | ·49 | ·65 |
| 7·85 | 30·32 | 21·83 | 34·30 | 20·53 | 31·89 | 17·78 | 29·17 | 16·39 | 26·99 | 18·44 | 31·37 | 16·95 | 26·45 |

### Division II.—South-Eastern Counties (*continued*).

| Kent (*continued*). | | | | West Sussex. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Acol, Margate. | | Welling, Bexley Heath. | | Aldwick, Bognor. | | Brighton. | | West Thorney. | | Chichester Museum. | | Bleak House, Hastings. | |
| 1 ft. 0 in. 60 ft. | | 6 ft. 0 in. 150 ft. | | 0 ft. 6 in. 8 ft. | | 4 ft. 0 in. 50 ft. | | 0 ft. 10 in. 10 ft. | | 0 ft. 6 in. 60 ft. | | 3 ft. 0 in. 80 ft. | |
| 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| ·49 | 3·23 | ·66 | 3·10 | 1·46 | 3·70 | 1·30 | 4·50 | 2·23 | 3·43 | 1·37 | 4·19 | 1·23 | 3·44 |
| ·96 | 1·62 | ·96 | 1·78 | ·91 | 2·26 | 1·50 | 2·83 | ·96 | 2·66 | 1·12 | 2·20 | 1·17 | 1·91 |
| 1·89 | 1·63 | 2·68 | 1·02 | 3·64 | 1·26 | 3·60 | 1·43 | 3·64 | ·48 | 4·01 | 1·11 | 2·28 | 1·61 |
| ·71 | ·39 | ·70 | ·54 | ·96 | ·44 | ·60 | ·54 | 1·74 | ·82 | 1·49 | ·55 | ·38 | ·24 |
| 1·90 | 2·60 | 2·65 | 4·32 | 1·37 | 2·39 | 1·30 | 3·48 | 1·17 | 2·30 | 1·41 | 2·65 | 2·00 | 3·10 |
| 1·08 | ·53 | 1·02 | 2·25 | ·72 | 1·60 | ·60 | ·65 | 1·58 | 1·83 | 1·30 | 2·23 | ·90 | 1·61 |
| ·48 | 2·82 | ·46 | 3·59 | ·23 | 2·48 | ·60 | 2·44 | ·36 | 1·73 | ·22 | 2·48 | ·18 | 1·46 |
| 2·21 | 4·48 | 1·43 | 3·28 | 1·04 | 2·73 | 2·20 | 3·63 | 1·29 | 4·84 | 1·39 | 4·39 | 1·73 | 2·71 |
| 1·42 | ·32 | 3·05 | ·17 | 2·51 | ·01 | 3·90 | ·35 | 3·11 | ·15 | 3·41 | ·03 | 2·11 | ·00 |
| 1·04 | 6·75 | 1·26 | 7·41 | 1·92 | 8·65 | 1·70 | 10·10 | 1·83 | 8·18 | 1·86 | 10·16 | 1·81 | 10·88 |
| 2·92 | 3·61 | 2·62 | 1·88 | 3·31 | 2·45 | 4·40 | 2·48 | 4·06 | 3·14 | 4·37 | 3·02 | 6·34 | 2·42 |
| ·74 | 1·82 | ·59 | ·79 | 1·04 | 2·00 | 1·15 | 2·70 | ·91 | 1·95 | 1·30 | 2·22 | ·66 | 1·50 |
| 15·84 | 29·80 | 18·08 | 30·13 | 19·11 | 29·97 | 22·85 | 35·13 | 22·88 | 31·51 | 23·25 | 35·68 | 20·79 | 30·88 |

## ENGLAND AND WALES.

### Division II.—South-Eastern Counties (*continued*).

| | West Sussex (*continued*). | | | | | | | | | | East Sussex | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Height of Rain-gauge above Ground ..... Sea-level..... | Dale Park, Arundel. 4 ft. 0 in. 316 ft. | | Battle. 1 ft. 3 in. ..... | | Chilgrove, Chichester. 0 ft. 6 in. 284 ft. | | Hurstpierpoint. 0 ft. 8 in. 120 ft. | | Petworth Rectory. 2 ft. 4 in. ..... | | Uckfield. 6 ft. 0 in. 140 ft. | |
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| January..... | 2·11 | 4·29 | 1·30 | 5·10 | 2·06 | 4·35 | 1·51 | 4·31 | 1·55 | 4·95 | ·94 | 5·26 |
| February ... | ·41 | 3·36 | 2·50 | 3·21 | 1·48 | 2·60 | ·92 | 2·77 | 1·40 | 2·34 | 1·03 | 1·63 |
| March ..... | 3·43 | 1·45 | 2·68 | 2·14 | 3·39 | 1·26 | 3·34 | 1·31 | 2·84 | 1·23 | 3·64 | 1·82 |
| April ..... | 1·02 | ·28 | 1·04 | ·26 | 1·48 | ·43 | ·81 | ·38 | 1·50 | ·22 | 1·04 | ·35 |
| May ..... | 1·31 | 2·72 | 2·43 | 3·87 | 1·60 | 2·89 | 1·34 | 3·05 | 1·88 | 3·36 | 1·94 | 3·37 |
| June ..... | ·82 | 1·74 | 1·48 | 1·44 | 1·33 | 2·27 | 1·03 | ·87 | 1·40 | 1·10 | 1·01 | 1·35 |
| July ..... | ·05 | 3·73 | ·88 | 2·94 | ·38 | 2·44 | ·42 | 3·48 | ·33 | 2·46 | ·46 | 4·85 |
| August ..... | 1·33 | 5·28 | 2·24 | 3·33 | 1·04 | 5·49 | 1·80 | 3·97 | 1·36 | 5·02 | 1·73 | 3·76 |
| September ... | 3·70 | ·12 | 4·00 | ·09 | 4·26 | ·30 | 3·24 | ·22 | 3·31 | ·16 | 3·06 | ·02 |
| October ..... | 1·63 | 12·23 | 2·15 | 11·88 | 1·88 | 9·95 | 2·58 | 10·59 | 1·50 | 10·19 | 2·09 | 11·23 |
| November ... | 3·61 | 3·86 | 6·28 | 3·16 | 4·35 | 3·50 | 5·03 | 3·48 | 4·67 | 4·43 | 5·56 | 3·06 |
| December ... | 1·29 | 3·20 | 1·32 | 2·18 | 1·42 | 2·97 | 1·37 | 1·93 | 1·28 | 3·37 | ·98 | 2·28 |
| Totals ..... | 20·71 | 42·26 | 28·30 | 39·60 | 24·67 | 38·45 | 23·39 | 36·36 | 23·02 | 38·83 | 23·48 | 38·97 |

### Div. II.—South-Eastern Counties (*continued*). Div. III.—South Midland Counties.

| | Hampshire (*continued*). | | Berkshire. | | | | Hertfordshire. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Height of Rain-gauge above Ground ..... Sea-level..... | Aldershot. 3 ft. 0 in. 325 ft. | | Royal Military College, Sandhurst. 5 ft. 6 in. 246 ft. | | Long Wittenham. 1 ft. 0 in. 170 ft. | | Watford House. 1 ft. 6 in. 190 ft. | | Berkhampstead. 1 ft. 6 in. 370 ft. | | Royston. 0 ft. 6 in. 266 ft. | |
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| January..... | ·92 | 3·64 | 1·61 | 2·77 | 1·06 | 3·48 | 1·01 | 1·72 | 1·30 | 3·85 | 1·09 | 3·39 |
| February ... | 1·23 | 2·08 | ·83 | 1·65 | 1·17 | 2·45 | ·97 | 2·81 | 1·04 | 2·55 | ·72 | 2·66 |
| March ..... | 2·94 | ·70 | 2·46 | ·78 | 3·23 | 1·02 | 2·65 | 1·10 | 3·11 | 1·39 | 3·75 | 1·35 |
| April ..... | 1·64 | ·71 | 1·42 | ·52 | 1·71 | ·93 | 1·10 | ·33 | 1·46 | ·49 | ·71 | ·30 |
| May ..... | 1·62 | 1·84 | 1·52 | 1·81 | 1·60 | 3·14 | 1·89 | 2·61 | 2·47 | 1·83 | 2·28 | 1·63 |
| June ..... | ·92 | 2·62 | ·90 | 2·51 | 1·76 | 3·36 | 2·44 | 2·11 | 1·62 | 2·49 | 1·26 | 2·13 |
| July ..... | ·34 | 1·60 | ·40 | 2·06 | ·44 | 2·19 | ·99 | 3·97 | ·29 | 3·01 | ·38 | 3·54 |
| August ..... | ·81 | 3·91 | 1·04 | 2·92 | ·93 | 2·85 | ·59 | 3·59 | ·68 | 3·69 | ·36 | 3·74 |
| September ... | 3·25 | ·54 | 1·98 | ·27 | 2·09 | ·19 | 2·74 | ·48 | 2·73 | ·51 | 1·96 | ·73 |
| October ..... | 1·58 | 5·80 | 1·43 | 4·72 | 1·22 | 6·40 | 1·10 | 6·20 | 1·63 | 6·55 | 1·32 | 6·56 |
| November ... | 2·52 | 3·54 | 2·44 | 2·95 | 2·23 | 2·71 | 2·26 | 2·28 | 3·04 | 2·93 | 2·36 | 1·84 |
| December ... | ·84 | 2·04 | ·35 | 1·41 | ·87 | 1·63 | ·66 | 2·39 | ·45 | 2·41 | ·48 | 1·25 |
| | 18·61 | 29·62 | 15·38 | 24·37 | 18·31 | 30·35 | 18·40 | 29·59 | 19·82 | 31·70 | 16·67 | 29·35 |

## ENGLAND AND WALES.

### Division II.—South-Eastern Counties (*continued*).

#### Hampshire.

| ntnor, f Wight. | | Ryde, Isle of Wight. | | Osborne, Isle of Wight. | | Fareham. | | Southampton, Ordnance Survey Office. | | The Wakes, Selborne. | | Liss, Petersfield. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| t. 0 in. 50 ft. | | 7 ft. 0 in. 15 ft. | | 3 ft. 0 in. 172 ft. | | 0 ft. 0 in. 26 ft. | | 1 ft. 3 in. 75 ft. | | 4 ft. 0 in. 500 ft. | | 0 ft. 6 in. ..... | |
| L. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| 9 | 5·74 | 2·35 | 4·98 | 1·70 | 4·48 | 2·84 | 4·09 | 2·85 | 5·05 | 1·97 | 3·86 | 1·92 | 4·10 |
| 55 | 2·48 | 1·55 | 3·22 | 1·43 | 2·51 | 1·18 | 3·50 | 2·11 | 4·08 | 1·58 | 3·11 | 1·65 | 3·17 |
| 16 | 1·29 | 3·77 | 1·10 | 3·30 | ·97 | 3·52 | 1·01 | 3·31 | 1·10 | 3·69 | 1·18 | 3·87 | 1·24 |
| 34 | ·59 | 1·70 | ·62 | 1·73 | ·67 | 2·86 | 1·30 | 2·46 | ·86 | 1·86 | ·89 | 2·11 | ·68 |
| 31 | 1·86 | 1·41 | 2·74 | 1·40 | 2·52 | 1·20 | 3·46 | 1·55 | 2·92 | 1·56 | 2·44 | 1·49 | 2·92 |
| 20 | 2·30 | 1·58 | 2·42 | 1·30 | 2·36 | ·86 | 1·36 | 1·41 | 2·56 | 1·13 | 2·35 | 1·14 | 3·50 |
| 38 | 1·36 | ·24 | 2·01 | ·15 | 2·54 | ·28 | 5·07 | ·32 | 4·07 | ·36 | 2·77 | ·32 | 2·64 |
| 82 | 2·44 | 1·00 | 3·97 | ·96 | 3·28 | ·53 | 4·71 | ·81 | 5·06 | 1·07 | 5·01 | 1·05 | 5·37 |
| 41 | ·14 | 2·85 | ·21 | 4·10 | ·04 | 4·40 | ·25 | 2·43 | ·13 | 3·02 | ·20 | 3·96 | ·13 |
| 17 | 8·24 | 1·72 | 11·10 | 1·27 | 8·10 | 2·10 | 6·89 | 1·42 | 8·74 | 2·03 | 7·95 | 1·93 | 10·30 |
| 49 | 3·18 | 4·12 | 3·59 | 3·92 | 3·79 | 3·18 | 4·81 | 4·27 | 4·82 | 4·20 | 4·83 | 4·41 | 5·07 |
| 75 | 2·51 | 1·58 | 3·24 | 1·41 | 3·70 | 1·80 | 2·66 | 2·32 | 3·32 | 1·24 | 3·59 | 1·37 | 3·69 |
| 87 | 32·73 | 23·87 | 39·20 | 22·67 | 34·96 | 24·75 | 39·11 | 25·26 | 42·71 | 23·71 | 38·18 | 25·22 | 42·81 |

### Division III.—South Midland Counties (*continued*).

| Iertford-ire (*cont.*). | | Oxford. | | | | Northampton. | | | | Bedford. | | Cambridge. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hitchin. | | Radcliffe Observatory. | | Banbury. | | Althorpe House. | | Welling-borough. | | Bedford. | | Wisbech Observatory. | |
| 2 ft. 0 in. 240 ft. | | 0 ft. 8 in. 210 ft. | | 7 ft. 0 in. 345 ft. | | 3 ft. 0 in. 310 ft. | | 0 ft. 2 in. ..... | | 3 ft. 0 in. 104 ft. | | 8 ft. 0 in. 18 ft. | |
| 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| 1·06 | 2·96 | ·97 | 3·05 | ·94 | 2·51 | ·95 | 2·52 | ·91 | 3·52 | ·95 | 2·62 | ·66 | 2·53 |
| ·56 | 2·38 | 1·44 | 1·87 | 1·44 | 2·35 | 1·45 | 1·88 | ·72 | 4·71 | ·55 | 2·25 | 1·27 | 1·77 |
| 4·14 | 1·22 | 2·47 | ·97 | 2·95 | 1·02 | 2·69 | 1·07 | 3·57 | 1·20 | 4·03 | 1·22 | 2·74 | 1·17 |
| ·94 | ·64 | 1·63 | ·91 | 1·37 | ·78 | 1·52 | ·97 | 1·34 | 1·23 | 1·08 | ·64 | ·62 | ·54 |
| 2·06 | 1·42 | 2·15 | 2·19 | 2·51 | 1·50 | 1·65 | 1·44 | 1·51 | 1·88 | 1·88 | 1·61 | 1·69 | 1·62 |
| 1·30 | 1·76 | 1·01 | 3·52 | 1·50 | 3·69 | ·93 | 3·16 | 1·06 | 2·36 | ·94 | 1·91 | 1·13 | 1·56 |
| ·17 | 4·77 | ·47 | 2·80 | ·88 | 3·66 | ·66 | 3·59 | ·76 | 3·67 | ·89 | 2·86 | ·54 | 4·37 |
| ·63 | 4·28 | ·79 | 3·09 | ·67 | 3·79 | ·73 | 3·55 | ·49 | 3·80 | ·39 | 3·88 | ·85 | 4·26 |
| 2·15 | ·59 | 2·94 | ·18 | 2·06 | ·29 | 2·53 | ·18 | 2·05 | ·41 | 1·61 | ·57 | 1·90 | ·37 |
| 1·35 | 7·07 | 1·56 | 5·41 | 2·10 | 4·56 | 1·45 | 3·72 | 1·72 | 4·54 | 1·06 | 5·02 | ·84 | 5·42 |
| 2·03 | 2·16 | 2·32 | 2·58 | 2·10 | 2·52 | 1·93 | 2·11 | 1·74 | 2·03 | 1·60 | 1·51 | 2·13 | 1·75 |
| ·77 | 1·01 | ·51 | 1·96 | 1·70 | 1·62 | ·72 | 1·31 | 1·01 | 1·31 | ·75 | ·69 | 1·04 | 1·16 |
| 17·16 | 30·26 | 18·26 | 28·53 | 20·22 | 28·29 | 17·21 | 25·50 | 16·88 | 30·66 | 15·73 | 24·78 | 15·41 | 26·52 |

## ENGLAND AND WALES.

| Div. III.—S. Midland Counties (*continued*). | Division IV.—Eastern Counties. | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cambridge (*continued*). | Essex. | | | | | | | | | | | |
| Height of Rain-gauge above Ground ..... Sea-level..... | Mid-level Sluice. 4 ft. 0 in. 16 ft. | | Epping. 6 ft. 0 in. 360 ft. | | Dorward's Hall, Witham. 1 ft. 6 in. 20? ft. | | Dunmow. 0 ft. 3 in. 234 ft. | | Bocking, Braintree. 3 ft. 0 in. 200 ft. | | Arkesden, Linton. 1 ft. 0 in. 300 ft. | |
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| January ..... | ·86 | 1·42 | ·63 | 3·45 | ·55 | 2·62 | ·63 | 2·78 | ·80 | 3·25 | [illegible] | [illegible] |
| February ... | ·65 | 2·08 | ·75 | 2·14 | 1·06 | 2·15 | ·42 | 1·80 | 1·24 | 2·08 | ·82 | [illegible] |
| March ..... | 2·57 | 1·27 | 2·44 | ·85 | 2·61 | 1·13 | 2·24 | 1·35 | 2·45 | 1·52 | 3·01 | [illegible] |
| April ..... | ·49 | ·57 | ·82 | ·42 | ·37 | ·34 | ·20 | ·16 | ·61 | ·38 | ·45 | [illegible] |
| May ..... | 2·57 | 2·09 | 1·45 | 2·95 | 2·11 | 1·16 | 2·12 | 1·20 | 2·24 | 1·15 | 2·07 | [illegible] |
| June ..... | 1·30 | 1·54 | 1·42 | 1·75 | 1·18 | 1·49 | 1·30 | 1·69 | 1·37 | 1·96 | 1·17 | [illegible] |
| July ..... | ·62 | 3·64 | ·62 | 1·82 | ·42 | 2·75 | ·52 | 3·07 | ·57 | 3·24 | ·71 | 4·22 |
| August ..... | 1·37 | 5·02 | 1·35 | 3·47 | 1·12 | 5·13 | 1·09 | 4·04 | 1·39 | 4·13 | ·75 | [illegible] |
| September ... | 1·86 | ·40 | 1·84 | ·50 | 1·80 | ·05 | 2·35 | ·58 | 1·95 | ·18 | 1·78 | [illegible] |
| October ..... | 1·01 | 6·19 | 1·10 | 6·22 | 1·14 | 5·56 | 1·03 | 6·67 | 1·18 | 5·56 | 1·14 | 5·06 |
| November ... | 1·98 | 1·72 | 1·97 | 1·75 | 1·99 | 1·50 | 2·43 | 2·15 | 2·44 | 2·25 | 2·42 | 1·69 |
| December ... | 1·03 | 1·18 | ·41 | 1·62 | 1·05 | 1·11 | ·65 | 1·51 | ·70 | 1·34 | ·76 | 1·35 |
| Totals ..... | 16·31 | 27·12 | 14·80 | 26·94 | 15·40 | 24·99 | 14·98 | 27·00 | 16·94 | 27·04 | 15·98 | 25·[illegible] |

| Division V.—South Western Counties (*continued*). | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wiltshire (*continued*). | | | | | Dorsetshire. | | | | | | Devonshire. | |
| Height of Rain-gauge above Ground ..... Sea-level..... | Marlborough. 4 ft. 0 in. 500 ft. | | Castle House, Calne. 0 ft. 11 in. 250 ft. | | Encombe, Wareham. 0 ft. 6 in. 150 ft. | | Little Bridy. 0 ft. 4 in. 348 ft. | | Bridport. 0 ft. 11 in. 85 ft. | | Saltram Gardens. 0 ft. 3 in. 96 ft. | |
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| January..... | 1·06 | 3·90 | 1·66 | 3·65 | 1·87 | 3·60 | 3·43 | 5·57 | 3·40 | 4·60 | 3·31 | [illegible] |
| February ... | 1·64 | 2·11 | 1·09 | 2·77 | 2·15 | 4·68 | 2·29 | 4·42 | 1·56 | 3·70 | 2·90 | [illegible] |
| March ..... | 3·22 | 1·16 | 2·42 | ·91 | 3·15 | 1·25 | 2·99 | 1·65 | 2·23 | 1·29 | 2·43 | [illegible] |
| April ..... | 1·89 | 1·22 | 1·78 | ·73 | 1·16 | 1·64 | 1·31 | ·81 | 1·29 | ·69 | 1·29 | [illegible] |
| May ..... | 1·64 | 2·47 | 1·09 | 2·25 | 1·45 | 2·39 | 1·00 | 3·22 | ·84 | 2·42 | 1·02 | [illegible] |
| June ..... | 1·48 | 2·10 | 1·67 | 1·51 | 1·46 | 2·12 | 1·87 | 3·06 | 1·18 | 1·75 | 2·36 | [illegible] |
| July ..... | ·62 | 2·49 | ·67 | 2·89 | ·53 | 1·64 | ·38 | 1·62 | ·49 | 3·56 | 1·29 | [illegible] |
| August ..... | ·45 | 3·75 | ·66 | 4·17 | ·86 | 3·10 | ·89 | 4·46 | ·76 | 5·04 | ·89 | [illegible] |
| September ... | 2·24 | ·19 | 2·69 | ·12 | 2·26 | ·00 | 3·15 | ·03 | 2·91 | ·00 | 3·09 | [illegible] |
| October ..... | 1·96 | 7·32 | 2·14 | 5·37 | ·76 | 9·50 | 1·77 | 9·61 | 1·63 | 7·70 | 2·30 | [illegible] |
| November ... | 3·16 | 3·75 | 1·79 | 3·21 | 3·44 | 3·98 | 4·04 | 5·99 | 2·57 | 5·33 | 4·05 | [illegible] |
| December ... | 1·93 | 2·34 | 2·51 | 2·34 | 2·07 | 3·50 | 4·02 | 4·68 | 3·21 | 4·23 | 3·29 | [illegible] |
| ... | 21·29 | 32·80 | 20·17 | 29·92 | 21·16 | 37·40 | 27·14 | 45·12 | 22·07 | 40·31 | 28·22 | 45·49 |

## ENGLAND AND WALES.

### Division IV.—Eastern Counties (*continued*).

| Suffolk. | | | Norfolk. | | | | | | | | Div. V.—S.-W. Coun. Wiltshire. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ndis-rgh. | Culford, Bury St. Edmunds. | | Diss. | | Norwich. | | Egmere, Fakenham. | | Holkham. | | Baverstock. | |
| 1 in. ..... | 1 ft. 2 in. ..... | | 0 ft. 6 in. 115 ft. | | 0 ft. 3 in. 50 ft. | | 4 ft. 8 in. 150? ft. | | 0 ft. 0 in. 39 ft. | | 3 ft. 0 in. 300 ft. | |
| 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| 2·87 | ·83 | 2·77 | ·80 | 2·70 | ·65 | 2·03 | ·46 | 1·59 | ·53 | 2·00 | 1·40 | 4·15 |
| 1·58 | 1·36 | 2·46 | 1·10 | 2·22 | 1·48 | 2·86 | 1·30 | 2·47 | 1·47 | 2·53 | 1·40 | 2·10 |
| 2·24 | 3·09 | 2·16 | 2·50 | 2·66 | 2·43 | 2·66 | 2·29 | 2·98 | 2·40 | 2·77 | 2·95 | 1·05 |
| ·29 | ·38 | ·28 | ·40 | ·43 | ·17 | ·35 | ·23 | ·38 | ·28 | ·35 | 2·40 | ·90 |
| 1·88 | 2·66 | 1·96 | 2·30 | 1·36 | 2·63 | 1·06 | 1·56 | 1·44 | 1·40 | 1·48 | 1·45 | 3·00 |
| 2·05 | 1·04 | 1·20 | 1·60 | 1·19 | 1·40 | 1·21 | 1·41 | 1·03 | 1·20 | 1·00 | 1·25 | 2·20 |
| 4·10 | ·49 | 4·01 | ·54 | 5·00 | 1·26 | 3·85 | ·62 | 6·16 | ·50 | 6·07 | ·40 | 1·70 |
| 4·29 | ·59 | 3·94 | ·73 | 4·30 | ·98 | 3·44 | ·96 | 3·09 | 1·00 | 3·23 | 1·15 | 2·80 |
| ·05 | 1·37 | ·04 | 1·68 | ·04 | 1·50 | ·00 | 1·21 | ·09 | 1·15 | ·10 | 2·50 | ·10 |
| 7·11 | 1·16 | 7·22 | 1·00 | 7·46 | 1·70 | 5·83 | ·90 | 4·63 | ·95 | 4·65 | 2·10 | 6·80 |
| 1·43 | 2·84 | 1·59 | 2·10 | ·30 | 2·34 | 1·89 | 2·01 | 1·50 | 2·20 | 1·70 | 2·45 | 4·20 |
| ·96 | ·63 | ·68 | ·60 | ·78 | 1·25 | 1·33 | 1·21 | ·93 | 1·42 | ·80 | 1·95 | 2·10 |
| 28·85 | 16·44 | 28·31 | 15·35 | 28·44 | 17·79 | 26·51 | 14·16 | 26·29 | 14·50 | 26·68 | 21·40 | 31·10 |

### Division V.—South-Western Counties (*continued*).

| Devonshire (*continued*). | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| orrhill, ybridge. | | Goodamoor, Plympton. | | High Wick, Newton Bushel. | | Westbrook, Teignmouth. | | Dawlish. | | Broadhembury. | | Cove, Tiverton. | |
| ft. 4 in. 240 ft. | | 0 ft. 2 in. 580 ft. | | 1 ft. 6 in. 250 ft. | | 0 ft. 3 in. 50 ft. | | 0 ft. 8 in. 62 ft. | | 2 ft. 4 in. 600 ft. | | 0 ft. 10 in. 450 ft. | |
| 64. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| 38 | 7·58 | 4·24 | 7·58 | 3·31 | 6·56 | 3·13 | 6·60 | 2·20 | 4·51 | 2·74 | 4·13 | 2·38 | 5·52 |
| 61 | 4·93 | 3·51 | 5·58 | 1·89 | 4·51 | 1·52 | 2·95 | 1·46 | 4·65 | 2·06 | 3·69 | 2·62 | 5·08 |
| 03 | 3·29 | 2·93 | 3·91 | 3·18 | 2·00 | 3·34 | 2·44 | 3·42 | 2·04 | 2·99 | 1·90 | 2·44 | 2·42 |
| 68 | ·69 | 1·67 | ·98 | 1·04 | ·63 | 1·52 | 1·00 | 1·31 | ·77 | ·96 | ·48 | 1·54 | ·91 |
| 37 | 3·71 | 1·32 | 3·74 | 1·82 | 3·58 | 1·28 | 3·11 | 1·32 | 3·29 | 1·10 | 3·85 | 1·20 | 3·96 |
| 59 | 1·31 | 2·79 | 1·26 | 1·34 | 2·78 | 1·18 | 2·35 | ·74 | 2·05 | 1·38 | 1·35 | 1·88 | 1·79 |
| | 3·33 | 1·63 | 4·46 | ·54 | 3·40 | ·30 | 3·15 | ·44 | 2·26 | ·75 | 2·83 | ·97 | 3·31 |
| 10 | 5·90 | 1·10 | 7·36 | 1·23 | 4·82 | 1·10 | 4·39 | ·83 | 3·57 | 1·08 | 4·27 | 1·50 | 5·06 |
| 55 | ·05 | 5·23 | ·08 | 1·93 | ·00 | 2·60 | ·00 | 1·86 | ·00 | 3·93 | ·01 | 3·99 | ·03 |
| 02 | 7·90 | 2·65 | 10·36 | 1·66 | 7·66 | 1·58 | 8·08 | 1·38 | 7·91 | 2·09 | 6·54 | 2·35 | 5·74 |
| 40 | 6·02 | 6·51 | 6·80 | 3·98 | 6·08 | 3·16 | 3·83 | 3·19 | 4·22 | 2·68 | 4·66 | 4·65 | 5·95 |
| 41 | 4·80 | 4·71 | 5·89 | 3·53 | 4·66 | 1·35 | 4·13 | 2·52 | 3·57 | 3·61 | 3·44 | 2·96 | 4·73 |
| 14 | 49·51 | 38·29 | 58·00 | 25·40 | 46·68 | 22·06 | 42·03 | 20·67 | 38·84 | 25·37 | 37·15 | 28·48 | 44·50 |

## ENGLAND AND WALES.

### Division V.—South-Western Counties (*continued*).

| Height of Rain-gauge above Ground ..... Sea-level..... | Devonshire (*continued*). Castle Hill, South Molton. 3 ft. 0 in. 150 ft. | | Great Torrington. 3 ft. 10 in. 450 ft. | | Barnstaple. 0 ft. 6 in. 31 ft. | | Cornwall. Helston. 5 ft. 0 in. 115 ft. | | Penzance. 3 ft. 0 in. 94 ft. | | Tehidy Pa Redruth 0 ft. 0 in. 100 ft. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865 |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| January ..... | 1·84 | 5·50 | 2·12 | 5·58 | 1·74 | 4·95 | 2·70 | 6·02 | 3·36 | 6·90 | 3·80 | 5·4 |
| February ... | 1·95 | 4·37 | 2·23 | 3·13 | 2·15 | 3·98 | 2·37 | 4·63 | 1·66 | 5·63 | 1·82 | 3·4 |
| March ..... | 3·14 | 3·57 | 2·62 | 3·33 | 2·56 | 2·99 | 2·64 | 2·39 | 2·63 | 2·84 | 2·30 | 2·5 |
| April ..... | 2·23 | 1·01 | 1·53 | 1·43 | 2·04 | 1·45 | 1·57 | 1·44 | 1·28 | 1·03 | 1·35 | 1·2 |
| May ..... | 1·58 | 4·09 | ·81 | 3·73 | 1·35 | 3·18 | 1·46 | 2·34 | 1·33 | 3·12 | 1·60 | 3·4 |
| June ..... | 3·82 | 2·10 | 3·47 | 1·33 | 3·03 | 2·26 | 1·59 | 1·93 | 1·76 | 1·42 | 1·60 | 5 |
| July ..... | 1·27 | 4·63 | 1·17 | 3·14 | ·89 | 3·02 | ·77 | 4·09 | ·77 | 3·29 | 1·05 | 4·4 |
| August ..... | 2·50 | 6·77 | 1·52 | 5·02 | 2·11 | 4·52 | ·50 | 5·64 | 1·25 | 4·35 | 1·12 | 5·5 |
| September ... | 5·51 | ·44 | 4·32 | ·10 | 4·29 | ·26 | 3·33 | ·05 | 4·03 | ·10 | 3·33 | ·1 |
| October ..... | 2·73 | 5·68 | 3·77 | 5·39 | ·64 | 5·57 | 3·32 | 7·75 | 2·67 | 8·21 | 3·70 | 5·1 |
| November ... | 4·51 | 5·17 | 4·17 | 4·44 | 3·54 | 4·04 | 3·90 | 4·93 | 5·15 | 5·89 | 3·40 | 4·7 |
| December ... | 2·47 | 3·16 | 3·15 | 3·74 | 2·09 | 3·14 | 4·41 | 3·53 | 3·94 | 4·80 | 4·20 | 4·2 |
| Totals ..... | 33·55 | 46·49 | 30·88 | 40·36 | 26·43 | 39·36 | 28·56 | 44·74 | 29·83 | 47·58 | 29·27 | 38·9 |

### Div. V.—S.W. Counties (*continued*). Division VI.—West Midland Counties.

| Height of Rain-gauge above Ground ..... Sea-level..... | Somerset (*continued*). Batheaston. 2 ft. 0 in. 226 ft. | | Gloucester. Bristol, Park-row. 6 ft. 0 in. 140 ft. | | Clifton. 0 ft. 6 in. 192 ft. | | Cirencester. 1 ft. 2 in. 446 ft. | | The Spa, Gloucester. 3 ft. 6 in. 50 ft. | | Shropshire Haughton Hall, Shifna 4 ft. 6 in 450 ft. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865 |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in |
| January ..... | 1·30 | 2·67 | 1·66 | 3·21 | 1·56 | 3·76 | 1·82 | 4·21 | 1·12 | 2·17 | ·73 | 3·1 |
| February ... | 1·22 | 1·51 | 1·74 | 2·96 | 1·88 | 2·88 | 1·93 | 2·50 | 1·27 | 1·62 | 1·39 | 1·7 |
| March ..... | 2·19 | ·86 | 2·41 | 1·12 | 2·62 | 1·16 | 3·08 | 1·40 | 2·28 | ·78 | 1·59 | 1·3 |
| April ..... | 1·69 | ·77 | 1·56 | ·70 | 1·40 | ·73 | 1·40 | 1·25 | ·55 | ·79 | 1·40 | 1·1 |
| May ..... | ·88 | 1·89 | ·70 | 2·11 | ·86 | 1·99 | 1·50 | 1·92 | 1·36 | 1·79 | 1·28 | 1·6 |
| June ..... | 1·54 | 1·28 | 2·06 | 1·53 | 2·12 | 1·58 | 1·35 | 2·05 | ·90 | 1·37 | 1·22 | 1·3 |
| July ..... | ·61 | 3·84 | ·94 | 3·03 | 1·00 | 4·23 | ·88 | 5·50 | ·56 | 3·60 | ·58 | 1·4 |
| August ..... | ·62 | 5·09 | ·88 | 8·46 | 1·12 | 8·51 | 1·24 | 4·00 | ·76 | 2·16 | 1·36 | 3·0 |
| September ... | 2·58 | ·05 | 3·56 | ·05 | 3·36 | ·02 | 3·68 | ·08 | 2·16 | ·09 | 1·50 | ·1 |
| October ..... | 1·37 | 5·37 | 1·98 | 4·67 | 1·90 | 4·97 | 2·25 | 6·46 | 1·79 | 3·31 | 1·80 | 3·2 |
| November ... | 1·46 | 3·91 | 2·36 | 3·25 | 2·95 | 3·25 | 3·30 | 3·67 | 2·26 | 2·31 | 1·80 | 1·8 |
| December ... | 2·50 | 2·72 | 2·08 | 2·73 | 1·98 | 3·42 | 2·25 | 2·78 | 2·10 | 1·82 | 1·98 | 1·1 |
| .. | 17·96 | 29·96 | 21·93 | 33·82 | 22·75 | 36·50 | 24·68 | 35·82 | 17·11 | 21·81 | 17·23 | 23·3 |

# ENGLAND AND WALES.

## Division V.—South-Western Counties (*continued*).

| stitu-uro. | Cornwall (*continued*). Bodmin. | | Treharrock House, Wadebridge. | | Rosecarrock, Port Isaac. | | Somerset. Taunton. | | Langport, Long Sutton. | | Sherborne Reservoir, E. Harptree. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ) in. t. | 2 ft. 6 in. 325 ft. | | 3 ft. 6 in. 308 ft. | | 3 ft. 0 in. 210 ft. | | 1 ft. 6 in. 38 ft. | | 0 ft. 7 in. ..... | | 5 ft. 0 in. 360 ft. | |
| 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| 6·40 | 4·34 | 6·91 | 2·37 | 5·31 | 3·09 | 4·81 | 1·65 | 3·72 | 1·59 | 3·23 | 2·24 | 5·18 |
| 4·28 | 2·25 | 4·87 | 2·01 | 3·51 | 1·71 | 3·77 | 1·46 | 2·48 | 1·24 | 2·28 | 2·17 | 4·25 |
| 2·79 | 3·19 | 2·55 | 2·34 | 2·09 | 1·88 | 2·00 | 2·94 | 1·40 | 2·60 | ·99 | 3·56 | 1·81 |
| 1·07 | 1·40 | 1·52 | 1·31 | 1·10 | 1·59 | ·63 | 1·96 | ·94 | 1·95 | 1·10 | 1·68 | ·63 |
| 2·58 | 1·48 | 3·05 | 1·89 | 3·03 | 1·62 | 2·77 | ·90 | 3·24 | 1·00 | 3·19 | ·85 | 2·83 |
| 1·79 | 2·82 | 1·85 | 2·26 | 1·75 | 2·30 | 1·60 | 1·17 | 1·50 | 1·86 | 1·75 | 2·11 | 1·76 |
| 4·31 | 1·30 | 3·51 | 1·27 | 4·59 | 1·20 | 3·44 | ·70 | 2·34 | ·66 | 2·57 | 1·04 | 4·11 |
| 5·33 | 1·50 | 5·28 | 1·62 | 4·42 | 1·54 | 5·09 | ·68 | 4·77 | ·71 | 4·56 | 1·05 | 5·84 |
| ·65 | 4·83 | ·11 | 4·15 | ·13 | 4·36 | ·16 | 2·08 | ·00 | 3·72 | ·00 | 4·01 | ·10 |
| 9·09 | 3·56 | 7·98 | 2·60 | 6·81 | 2·91 | 5·65 | 2·20 | 6·41 | 1·65 | 5·51 | 2·01 | 6·99 |
| 4·97 | 5·50 | 7·00 | 4·83 | 5·07 | 4·57 | 5·38 | 2·24 | 3·94 | 2·36 | 3·46 | 3·64 | 5·02 |
| 5·00 | 4·96 | 4·35 | 3·39 | 3·72 | 3·44 | 2·92 | 3·02 | 2·88 | 3·17 | 2·93 | 4·13 | 3·44 |
| 42·26 | 37·13 | 48·98 | 30·24 | 41·53 | 30·21 | 38·22 | 21·00 | 33·62 | 22·51 | 31·57 | 28·49 | 41·96 |

## Division VI.—West Midland Counties (*continued*).

| ɔpshire (*continued*). hurch. | | Hengoed, Oswestry. | | Worcester. Northwick Park. | | West Malvern. | | Lark Hill, Worcester. | | Orleton. | | Warwick. Rugby. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 in. ..... | | 6 ft. 0 in. 471 ft. | | 1 ft. 6 in. ..... | | 1 ft. 3 in. 900 ft. | | 1 ft. 0 in. 157 ft. | | 0 ft. 9 in. 200 ft. | | 2 ft. 4 in. 384 ft. | |
| , 1865. | | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| in. | | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| 2·60 | | 1·52 | 3·75 | 1·20 | 2·47 | 1·31 | 1·56 | 1·01 | 3·19 | 1·31 | 2·58 | ·92 | 2·04 |
| 1·17 | | 1·94 | 2·34 | 1·60 | 3·01 | 1·61 | 2·87 | 1·58 | 1·99 | 1·73 | 2·66 | 1·45 | 2·17 |
| 1·48 | | 4·05 | 1·59 | 3·63 | 1·11 | 2·64 | ·91 | 2·63 | ·83 | 2·51 | 1·13 | 2·81 | 1·22 |
| 1·45 | | 1·99 | 1·12 | 1·77 | 1·44 | 1·37 | 1·45 | 1·19 | 1·09 | 1·38 | 1·10 | 1·48 | ·68 |
| 2·30 | | 2·12 | 5·44 | 2·11 | 1·88 | 1·43 | 2·91 | 1·85 | 2·25 | 1·78 | 3·56 | 1·39 | 1·62 |
| ·75 | | 2·26 | 2·26 | 1·29 | ·65 | 1·38 | 2·17 | 1·00 | 1·88 | 1·86 | 2·05 | ·87 | 2·47 |
| 1·56 | | ·96 | 2·07 | ·41 | 6·21 | ·86 | 3·36 | ·72 | 4·11 | ·82 | 2·68 | ·27 | 3·85 |
| 5·43 | | 1·49 | 7·21 | ·36 | 3·11 | ·37 | 3·41 | ·37 | 2·99 | ·79 | 4·80 | ·73 | 3·47 |
| ·26 | | 3·08 | ·18 | 2·70 | ·08 | 3·59 | ·13 | 2·65 | ·10 | 2·69 | ·11 | 1·36 | ·24 |
| 4·07 | | 3·05 | 5·86 | 2·24 | 5·43 | 2·37 | 4·36 | 2·12 | 5·20 | 2·23 | 4·83 | 1·67 | 4·60 |
| 2·00 | | 3·18 | 4·09 | 2·47 | 2·89 | 2·47 | 2·98 | 2·64 | 2·91 | 2·36 | 2·98 | 1·65 | 2·29 |
| 2·17 | | 1·65 | 2·43 | 3·30 | 2·07 | 2·96 | 1·71 | 2·63 | 1·50 | 2·33 | 1·40 | 1·79 | 1·29 |
| 25·24 | | 27·29 | 38·34 | 23·08 | 30·35 | 22·36 | 27·82 | 20·39 | 28·04 | 21·79 | 29·88 | 16·39 | 25·94 |

## ENGLAND AND WALES.

### Division VI.—West Midland Counties (*continued*).

#### Warwick (*continued*).

| Height of Rain-gauge above Ground ..... Sea-level..... | Edgbaston, Birmingham. 1 ft. 6 in. 510 ft. | | Birmingham. 0 ft. 10 in. 340 ft. | |
|---|---|---|---|---|
| | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. |
| January ..... | 1·22 | 3·17 | 1·15 | 3·08 |
| February ... | 2·02 | 2·60 | 1·77 | 2·63 |
| March ..... | 3·47 | 1·43 | 3·44 | 1·23 |
| April ..... | 1·41 | 1·33 | 1·45 | ·60 |
| May ..... | 1·60 | 3·00 | 1·59 | 2·87 |
| June ..... | 1·61 | 2·34 | 1·63 | 2·36 |
| July ..... | ·83 | 3·85 | ·88 | 3·89 |
| August ..... | ·66 | 4·47 | ·48 | 4·59 |
| September ... | 3·13 | ·18 | 3·46 | ·21 |
| October ..... | 2·75 | 5·63 | 2·56 | 5·06 |
| November ... | 2·67 | 2·31 | 2·42 | 2·25 |
| December ... | 2·74 | 1·25 | 2·68 | 1·10 |
| Totals ..... | 24·11 | 31·56 | 23·51 | 29·87 |

### Division VII.—North Midland Counties

#### Leicester.

| Height of Rain-gauge above Ground ..... Sea-level..... | Wigston. 0 ft. 6 in. 220 ft. | | Thornton Reservoir. 2 ft. 8 in. 420? ft. | | Belvoir Castle. 1 ft. 0 in. 237 ft. | |
|---|---|---|---|---|---|---|
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. |
| January ..... | ·88 | 2·33 | ·84 | 1·98 | ·57 | 2·59 |
| February ... | 1·71 | 2·43 | 2·12 | 1·80 | ·98 | 2·06 |
| March ..... | 2·42 | 1·01 | 2·70 | ·89 | 2·75 | 1·31 |
| April ..... | 1·74 | ·40 | 1·30 | ·40 | 1·89 | ·67 |
| May ..... | 1·88 | 3·00 | 2·40 | 2·17 | ·96 | 2·34 |
| June ..... | 1·36 | 2·29 | 2·12 | 2·42 | 1·33 | 1·41 |
| July ..... | ·30 | 3·25 | ·44 | 3·25 | ·25 | 3·00 |
| August ..... | ·54 | 3·54 | ·51 | 4·20 | ·56 | 3·54 |
| September ... | 1·50 | ·22 | 1·70 | ·26 | 1·69 | ·21 |
| October ..... | 1·66 | 4·88 | 1·67 | 5·74 | 1·34 | 4·78 |
| November ... | 2·19 | 2·42 | 2·48 | 1·97 | 1·99 | 2·38 |
| December ... | 1·42 | 1·03 | 1·26 | ·74 | 2·03 | ·93 |
| Totals ..... | 17·60 | 26·80 | 19·54 | 25·32 | 16·34 | 25·22 |

### Division VII.—North Midland Counties (*continued*).

#### Nottinghamshire.

| Height of Rain-gauge above Ground ..... Sea-level..... | Welbeck. 3 ft. 10 in. ..... | | East Retford. 2 ft. 0 in. 50 ft. | |
|---|---|---|---|---|
| | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. |
| January ..... | 1·03 | 2·03 | ·86 | 1·96 |
| February ... | 1·32 | 1·69 | 1·46 | 1·61 |
| March ..... | 2·03 | ·69 | 2·09 | 1·44 |
| April ..... | 1·34 | ·95 | 1·18 | 1·07 |
| May ..... | 4·18 | 3·21 | 4·74 | 3·21 |
| June ..... | 1·33 | 1·08 | 1·88 | 1·45 |
| July ..... | 1·17 | 2·86 | 1·07 | 2·86 |
| August ..... | 1·89 | 3·74 | 1·76 | 2·47 |
| September ... | 1·93 | ·58 | 2·02 | ·16 |
| October ..... | 2·94 | 4·86 | 2·91 | 4·79 |
| ·ber ... | 2·21 | 2·21 | 2·16 | 2·09 |
| ·er ... | 1·23 | ·61 | 1·97 | ·63 |
| ..... | 22·60 | 24·51 | 24·10 | 23·74 |

#### Derbyshire.

| Height of Rain-gauge above Ground ..... Sea-level..... | Derby. 5 ft. 0 in. 180 ft. | | Chesterfield. 3 ft. 6 in. 248 ft. | | Comb's Moss. 3 ft. 6 in. 1669 ft. | |
|---|---|---|---|---|---|---|
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. |
| January ..... | 1·08 | 2·00 | 1·02 | 1·85 | 2·23 | 3·00 |
| February ... | 2·52 | 2·06 | 1·87 | 1·83 | 3·49 | 2·89 |
| March ..... | 2·49 | 1·04 | 2·67 | ·68 | 2·10 | 1·63 |
| April ..... | 2·10 | ·97 | 1·92 | 1·87 | 1·33 | 1·72 |
| May ..... | 1·67 | 2·63 | 1·31 | 2·90 | 4·67 | 3·76 |
| June ..... | 1·21 | 1·83 | ·81 | 1·13 | 4·25 | 1·18 |
| July ..... | ·74 | 2·68 | ·31 | 2·77 | 2·37 | 3·57 |
| August ..... | ·71 | 3·25 | 1·03 | 4·29 | 3·72 | 5·93 |
| September ... | 3·23 | ·15 | 2·73 | ·05 | 3·70 | ·51 |
| October ..... | 2·07 | 5·20 | 2·96 | 6·13 | 3·52 | 8·99 |
| November ... | 1·99 | 1·90 | 3·18 | 2·71 | 7·10 | 6·67 |
| December ... | 1·93 | ·75 | 1·53 | ·88 | 3·70 | 2·18 |
| ..... | 21·74 | 24·46 | 21·34 | 27·09 | 42·18 | 42·03 |

# ENGLAND AND WALES.

## Division VII.—North Midland Counties (*continued*).

### Lincolnshire (*continued*).

| ...ear. | Lincoln. | | Market Rasen. | | Gainsborough. | | Brigg. | | Grimsby. | | New Holland. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ...ion. ...t. | 3 ft. 6 in. 26 ft. | | 3 ft. 6 in. 100 ft. | | 3 ft. 6 in. 76 ft. | | 3 ft. 6 in. 16 ft. | | 15 ft. 0 in. 42 ft. | | 3 ft. 6 in. 18 ft. | |
| 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| 1·82 | ·83 | 1·28 | ·53 | 1·58 | ·84 | 1·40 | ·81 | 1·68 | ·97 | ·62 | ·83 | 1·37 |
| 1·90 | 1·40 | 1·12 | ·60 | 1·75 | 1·05 | 1·30 | 1·60 | 1·86 | 1·43 | 1·18 | 1·49 | 1·72 |
| 1·21 | 1·85 | ·99 | ·97 | 1·18 | 1·42 | ·64 | 1·27 | 1·18 | ·86 | 1·82 | 1·63 | 1·28 |
| ·30 | ·93 | ·42 | ·44 | 0·50 | ·89 | ·71 | ·95 | ·38 | ·19 | ·57 | 1·01 | ·59 |
| 2·23 | 1·41 | 1·91 | ·54 | 4·53 | 1·71 | 2·70 | 1·47 | 4·35 | 1·12 | 1·31 | 1·17 | 2·76 |
| 1·74 | 1·86 | 1·56 | 1·89 | 2·09 | 1·09 | 1·48 | 1·91 | ·96 | 1·19 | 1·25 | 1·12 | 1·13 |
| 5·29 | ·57 | 2·68 | ·25 | 1·89 | ·65 | 2·81 | ·68 | 1·97 | ·36 | 1·18 | ·27 | 1·77 |
| 2·92 | 1·22 | 3·28 | 1·47 | 2·97 | 3·49 | 3·32 | 1·57 | 4·57 | 1·92 | 4·65 | 1·40 | 4·91 |
| ·40 | 1·60 | ·00 | 2·28 | ·04 | 1·44 | ·17 | 2·44 | ·33 | 1·36 | ·10 | 2·05 | ·22 |
| 4·62 | 1·72 | 5·13 | 1·50 | 4·35 | 2·14 | 4·33 | 2·10 | 4·61 | 1·67 | 4·33 | 1·97 | 4·15 |
| 2·21 | 2·09 | 2·20 | 2·64 | 1·95 | 2·33 | 2·07 | 3·05 | 2·11 | 2·66 | 3·42 | 2·12 | 2·07 |
| 1·15 | 1·51 | ·25 | 1·56 | ·49 | 1·05 | ·56 | 1·75 | 1·17 | 1·64 | 1·41 | 2·17 | ·79 |
| 25·79 | 16·99 | 20·82 | 14·67 | 23·32 | 18·10 | 21·49 | 19·60 | 25·17 | 15·37 | 21·84 | 17·23 | 22·76 |

## Division VIII.—North-Western Counties.

| Cheshire. | | | | Lancashire. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ...clesfield. | | Quarry Bank. | | Manchester. | | Waterhouses. | | Bolton-le-Moors. | | Rufford, Ormskirk. | | Standish, Wigan. | |
| ...ft. 6 in. 539 ft. | | 0 ft. 8 in. 295 ft. | | 2 ft. 7 in. 106 ft. | | 3 ft. 6 in. 345 ft. | | 3 ft. 6 in. 286 ft. | | 0 ft. 8 in. 38 ft. | | 0 ft. 6 in. 300 ft. | |
| 64. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| ·30 | 2·21 | 1·37 | 2·55 | 1·68 | 3·11 | 1·25 | 2·79 | 3·61 | 4·20 | 1·95 | 2·40 | 2·30 | 2·94 |
| ·95 | 2·26 | 2·88 | 1·78 | 4·03 | 2·36 | 3·47 | 2·67 | 4·10 | 4·18 | 1·87 | 2·02 | 2·50 | 3·12 |
| ·73 | 1·46 | 2·12 | 1·81 | 2·01 | 1·67 | 1·96 | 1·18 | 3·06 | 1·74 | 2·47 | 1·61 | 3·12 | 1·99 |
| ·17 | 1·06 | 1·16 | 1·23 | 1·60 | 1·08 | 1·02 | 1·08 | 2·19 | 1·32 | 1·39 | 1·49 | 1·85 | 1·98 |
| ·48 | 2·95 | 2·08 | 3·23 | 3·17 | 3·19 | 4·08 | 2·91 | 3·29 | 3·21 | 2·05 | 3·63 | 2·39 | 3·96 |
| 3·04 | ·68 | 3·03 | 1·40 | 2·95 | ·96 | 2·54 | ·72 | 3·99 | ·63 | 3·37 | ·63 | 4·14 | ·53 |
| 1·81 | 3·00 | 1·45 | 2·64 | 1·69 | 3·00 | 1·90 | 2·71 | 3·10 | 3·39 | 1·85 | 2·27 | 2·49 | 3·88 |
| 2·53 | 4·25 | 2·00 | 3·81 | 2·37 | 3·84 | 2·45 | 4·14 | 3·63 | 6·18 | 1·79 | 4·38 | 2·19 | 5·10 |
| 4·02 | ·23 | 3·81 | ·44 | 4·01 | ·67 | 4·30 | ·70 | 4·74 | ·43 | 3·52 | ·38 | 4·67 | ·43 |
| 2·55 | 4·36 | 1·76 | 4·71 | 1·91 | 5·00 | 1·98 | 4·98 | 2·55 | 6·40 | 2·90 | 4·53 | 2·36 | 4·99 |
| 4·46 | 4·09 | 2·75 | 2·67 | 3·25 | 2·77 | 3·11 | 3·00 | 5·48 | 3·92 | 3·70 | 2·95 | 4·56 | 3·30 |
| 2·16 | ·64 | 1·92 | ·66 | 1·97 | ·74 | 1·93 | ·65 | 3·00 | 1·91 | 2·28 | 1·56 | 2·22 | 1·26 |
| 30·20 | 27·19 | 26·33 | 26·93 | 30·64 | 28·39 | 29·99 | 27·53 | 42·74 | 37·51 | 29·14 | 27·85 | 34·79 | 33·48 |

## ENGLAND AND WALES.

### Division VIII.—North-Western Counties (*continued*).

#### Lancashire (*continued*.)

| Height of Rain-gauge above Ground ..... Sea-level..... | Howick. 0 ft. 6 in. 72 ft. | | South Shore, Blackpool. 1 ft. 8 in. 29 ft. | | Stonyhurst. 1 ft. 3 in. 381 ft. | | Caton. 1 ft. 9 in. 120 ft. | | Holker, Cartmel. 4 ft. 8 in. 155 ft. | | Wray Cast. 4 ft. 9 in. 250 ft. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| January ..... | 3·00 | 2·30 | 1·65 | 1·90 | 3·30 | 4·11 | 3·04 | 2·95 | 3·18 | 3·86 | 7·28 | 7·1 |
| February ... | 4·75 | 2·65 | 1·60 | 3·40 | 4·61 | 3·63 | 3·51 | 3·27 | 3·75 | 3·59 | 5·13 | 3·9 |
| March ..... | 2·62 | 1·85 | 2·20 | 1·80 | 3·70 | 2·30 | 3·94 | 2·17 | 4·35 | 2·05 | 5·57 | 2·6 |
| April ..... | 1·50 | 1·40 | 1·65 | ·70 | 1·81 | 2·20 | 1·93 | ·97 | 2·18 | ·99 | 1·96 | 1·0 |
| May ..... | 2·15 | 5·95 | 1·70 | 3·45 | 2·93 | 5·21 | 2·95 | 4·89 | 2·92 | 5·34 | 2·35 | 5·3 |
| June ..... | 3·50 | ·30 | 3·10 | ·25 | 5·21 | ·69 | 4·76 | ·63 | 4·01 | ·70 | 4·20 | ·5 |
| July ..... | 1·75 | 2·90 | 1·40 | 2·35 | 2·25 | 3·21 | 2·63 | 2·21 | 3·16 | 2·29 | 3·98 | 2·9 |
| August ..... | 2·60 | 4·60 | 2·80 | 3·10 | 3·28 | 5·79 | 3·38 | 4·82 | 3·29 | 5·56 | 3·53 | 6·9 |
| September ... | 3·70 | ·40 | 2·85 | ·70 | 4·37 | 1·06 | 4·54 | 1·30 | 4·15 | 1·58 | 7·59 | 2·1 |
| October ..... | 2·24 | 4·40 | 2·60 | 4·50 | 2·40 | 6·69 | 2·47 | 5·21 | 3·45 | 6·34 | 3·49 | 7·1 |
| November ... | 4·00 | 3·00 | 4·95 | 2·90 | 5·07 | 4·01 | 4·99 | 3·62 | 4·24 | 3·69 | 7·26 | 6·2 |
| December ... | 2·60 | 1·80 | 2·30 | 1·50 | 2·87 | 1·69 | 3·79 | 2·32 | 4·88 | 2·36 | 8·72 | 5·0 |
| Totals ..... | 34·41 | 31·55 | 28·80 | 26·55 | 41·80 | 40·59 | 41·93 | 34·36 | 43·56 | 38·35 | 61·26 | 54·5 |

### Division IX.—Yorkshire (*continued*).

#### Yorkshire—West Riding (*continued*).

| Height of Rain-gauge above Ground ..... Sea-level..... | Wakefield. 4 ft. 0 in. 115 ft. | | Well Head, Halifax. 0 ft. 11 in. 487 ft. | | Ovenden Moor. 1 ft. 0 in. 1375 ft. | | Manor Road, Holbeck, water-works Office. 0 ft. 0 in. 95 ft. | | Roscup, Leeds. 0 ft. 0 in. 340 ft. | | Boston Spa. 0 ft. 11 in. 74 ft. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| January ..... | ·72 | 1·37 | 1·48 | 2·59 | 2·60 | 1·60 | ·64 | 1·30 | ·79 | 1·00 | ·96 | 1·66 |
| February ... | 1·71 | 1·43 | 2·13 | 2·13 | 2·90 | 3·30 | 1·41 | 1·57 | 1·41 | 2·00 | 1·50 | 2·43 |
| March ..... | 2·23 | ·56 | 2·99 | ·80 | 4·00 | 2·10 | 1·79 | ·56 | 2·19 | ·72 | 2·33 | 1·05 |
| April ..... | 1·80 | ·85 | 1·40 | 1·13 | 1·30 | 2·20 | 1·42 | 1·54 | 1·71 | ·96 | 1·33 | 1·51 |
| May ..... | 2·71 | 2·31 | 1·75 | 2·20 | 2·20 | 3·40 | 1·64 | 1·80 | 1·73 | 1·70 | 1·63 | 3·18 |
| June ..... | 1·57 | 1·31 | 1·54 | ·84 | 4·00 | 1·10 | ·91 | ·23 | 1·71 | ·63 | 2·72 | ·54 |
| July ..... | ·65 | 2·60 | ·89 | 2·19 | 1·40 | ·60 | ·70 | 2·59 | ·84 | 1·49 | 1·04 | 1·18 |
| August ..... | 1·57 | 3·04 | ·96 | 4·70 | 1·30 | 5·50 | ·89 | 5·98 | ·93 | 4·55 | 1·02 | 5·35 |
| September ... | 1·58 | ·15 | 2·45 | ·30 | 5·10 | 1·10 | 1·35 | ·19 | 1·61 | ·29 | 2·14 | ·39 |
| October ..... | 3·30 | 5·20 | 3·32 | 6·10 | 4·70 | 7·60 | 1·97 | 5·82 | 1·71 | 4·59 | 3·30 | 5·33 |
| November ... | 2·77 | 2·02 | 3·23 | 2·82 | 5·30 | 3·90 | 2·59 | 2·95 | 2·63 | 3·40 | 2·97 | 2·44 |
| December ... | 1·98 | ·87 | 1·50 | 2·16 | 3·90 | 2·60 | 1·73 | 1·25 | 1·69 | 1·33 | 2·81 | 1·28 |
| Totals ..... | 22·59 | 21·71 | 23·64 | 27·96 | 38·70 | 35·00 | 17·04 | 25·78 | 18·95 | 22·66 | 23·75 | 26·54 |

TABLE VI. (*continued*).

| | 1864. in. | 1865. in. |
|---|---|---|
| **Div. XIII.—South-Eastern Counties.** | | |
| Selkirk, Bowhill | 28·82 | 28·69 |
| N. Esk Reser, Penicuick | 35·98 | 36·70 |
| Berwick | 31·75 | 28·80 |
| Yester | 34·15 | 36·10 |
| East Linton | 29·92 | 23·87 |
| Glencorse | 35·80 | 34·60 |
| Invereak | 30·02 | 27·78 |
| Charlotte Square, Edinburgh | 28·09 | 23·65 |
| **Div. XIV.—South-Western Counties.** | | |
| Newmains, Castle Douglas | 44·88 | 36·42 |
| Auchinraith | 27·35 | 24·28 |
| Glasgow Observatory | 37·15 | 35·37 |
| Baillieston | 41·71 | 38·04 |
| Hillend House, Shotts | 32·10 | 24·18 |
| Girvan | 43·35 | 41·66 |
| Auchendrane House, Ayr | 36·81 | 31·06 |
| Manafield, Largs | 42·80 | 39·80 |
| Nither Place, Mearns | 51·75 | 38·38 |
| Paisley, Stanely Reservoir | 39·80 | 36·63 |
| Greenock | 55·80 | 49·43 |
| **Div. XV.—West Midland Counties.** | | |
| Balloch Castle | 49·87 | 45·20 |
| Aridarrock, Loch Long | 70·60 | 60·79 |
| Stirling, Polmaise Gardens | 36·00 | 32·60 |
| Pladda | 23·53 | 26·95 |
| Devaar, Campbeltown | 38·53 | 40·61 |
| Rhinns of Islay | 27·17 | 34·35 |
| M'Arthur's Head | 60·40 | 54·40 |
| Tarbert, Stonefield | 56·20 | 55·70 |
| Hafton, Dunoon | 68·51 | 56·42 |
| Otter House | 56·14 | 47·84 |
| Kilmory, Lochgilphead | 53·50 | 55·20 |
| Fladda | 62·30 | 68·20 |
| Inverary Castle | 47·50 | 40·10 |
| Oban | 62·43 | 54·25 |
| Lismore | 52·12 | 40·11 |
| Hynish, Tiree | 78·42 | 76·70 |
| Loch Eil Corran | 85·55 | 67·90 |
| Ardnamurchan | 46·17 | 40·78 |
| **Div. XVI.—East Midland Counties.** | | |
| Dollar | 36·62 | 36·20 |
| Loch Leven Sluice | 36·10 | 34·10 |
| Leven, Nookton | 29·75 | 25·77 |
| Dumblane, Kippenross | 38·20 | 32·35 |
| Deanston | 41·90 | 33·75 |
| Loch Katrine | 71·20 | 61·70 |
| Auchterarder House | 33·51 | 32·70 |
| Stronvar, Loch Earnhead | 71·67 | 62·11 |
| Trinity Gask | 37·20 | 30·55 |
| Scone Palace | 28·70 | 28·79 |
| Stanley | 28·60 | 27·46 |
| Dundee | 33·97 | 30·59 |
| Arbroath | 34·20 | 27·88 |
| Montrose | 29·99 | 34·26 |
| **Div. XVII.—North-Eastern Counties.** | | |
| Brechin, The Burn | 36·30 | 34·70 |
| Bogmuir | 33·30 | 30·20 |
| Banchory House | 26·10 | 32·40 |
| Braemar | 32·50 | 29·72 |
| Aberdeen | 27·95 | 27·68 |
| **Div. XVII.—North-Eastern Counties (*continued*).** | | |
| Castle Newe | 36·48 | 33·35 |
| Tillydesk, Ellon | 32·96 | 27·09 |
| Elgin Institution | 29·52 | 23·11 |
| **Div. XVIII.—North-Western Counties.** | | |
| Inverinate House, Loch Alsh | 62·30 | 56·73 |
| Cromarty | 23·32 | 19·51 |
| Ardross Castle, Alness | 35·34 | 29·68 |
| Oronsay | 92·86 | 46·98 |
| Raasay | 69·95 | 57·25 |
| Barrahead | 36·77 | 35·44 |
| S. Uist, Ushenish | 39·95 | 39·66 |
| Island Glass | 17·51 | 17·93 |
| Urquhart, Corrimony | 41·70 | 35·80 |
| Culloden | 24·76 | 24·96 |
| **Div. XIX.—Northern Counties.** | | |
| Dunrobin Castle | 28·16 | 21·06 |
| House of Tongue | 43·70 | 28·90 |
| Cape Wrath | 38·19 | 32·80 |
| Nosshead | 27·23 | 15·09 |
| Holburnhead | 18·14 | 24·91 |
| Pentland, Skerries | 31·94 | 26·05 |
| Balfour Castle | 30·75 | 25·45 |
| Sandwick | 33·28 | 34·21 |
| Sumburghead | 23·90 | 20·47 |
| Bressay | 43·00 | 32·10 |
| East Yell | 42·31 | 38·09 |
| **IRELAND.** | | |
| **Div. XX.—Munster.** | | |
| Cork | 34·61 | 43·01 |
| Valentia | 47·62 | 59·09 |
| Waterford | 34·46 | 41·02 |
| Portlaw | 40·27 | 47·25 |
| Killaloe | 35·64 | 46·04 |
| Ennis | 28·44 | 32·11 |
| **Div. XXI.—Leinster.** | | |
| Kilkenny | 35·18 | 30·43 |
| Portarlington | 42·45 | 43·84 |
| Birr Castle, Parsonstown | 27·04 | 31·90 |
| Tullamore | 23·98 | 26·92 |
| Bray, Fassaroe | 31·66 | 42·21 |
| Black Rock | 25·73 | 29·80 |
| Dublin | 29·75 | 29·23 |
| Glasnevin | 23·95 | 24·34 |
| **Div. XXII.—Connaught.** | | |
| Gort, Cregg Park | 33·89 | 38·43 |
| Queen's College, Galway | 58·07 | 48·90 |
| Doo Castle, Bunninadden | 31·89 | 39·62 |
| Hazlewood, Sligo | 37·64 | 41·81 |
| **Div. XXIII.—Ulster.** | | |
| Red Hills, Belturbet | 27·07 | 36·92 |
| Florence Court | 29·43 | 43·15 |
| Armagh Observatory | 34·82 | 37·93 |
| Miltown, Banbridge | 25·10 | 29·21 |
| Waringstown | 25·44 | 28·62 |
| Antrim | 29·74 | 29·41 |
| Moneydig, Garvagh | 31·76 | 37·86 |
| Londonderry | 35·03 | 39·24 |
| Leckpatrick, Strabane | 34·99 | 37·99 |
| Letterkenny | 46·32 | 50·46 |

## TABLE VII.—TABLES OF MONTHLY RAI

## ENGLAND AND WALES.

### Division I.—MIDDLESEX.

MIDDLESEX.

| Height of Rain-gauge above Ground ..... Sea-level..... | Hammersmith. 1 ft. 0 in. 12 ft. | | Camden Town. 0 ft. 4 in. 100 ft. | | Hackney. 0 ft. 6 in. 40 ft. | | Hampstead. 1 ft. 0 in. 360 ft. | | Harrow. 1 ft. 2 in. 354 ft. | | Lower Edmonton 0 ft. 9 in. ..... | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| January ..... | 1·00 | 2·98 | 1·07 | 3·63 | 1·06 | 3·27 | 1·25 | 3·50 | 1·24 | 2·41 | ·87 | 2·8 |
| February ... | ·84 | 2·18 | ·76 | 2·27 | ·80 | 2·04 | ·94 | 2·63 | ·92 | 2·72 | ·86 | 2·1 |
| March ..... | 2·42 | 1·17 | 2·61 | 1·09 | 2·54 | 1·08 | 2·85 | 1·09 | 2·15 | 1·01 | 2·27 | 1·1 |
| April ..... | ·76 | ·22 | ·92 | ·37 | 1·18 | ·46 | ·86 | ·33 | 1·30 | ·53 | ·78 | ·3 |
| May ..... | 1·51 | 3·44 | 1·54 | 3·40 | 1·62 | 3·67 | 1·74 | 3·13 | 1·94 | 3·00 | 1·43 | 2·7 |
| June ..... | 2·09 | ·78 | 1·68 | 1·71 | 1·44 | 1·91 | 2·25 | 1·71 | 2·09 | 1·96 | 1·83 | 1·9 |
| July ..... | ·21 | 1·38 | ·61 | 1·91 | ·50 | 2·21 | ·59 | 2·30 | ·51 | 2·44 | ·41 | 2·2 |
| August ..... | 1·22 | 4·46 | 1·30 | 4·97 | 1·22 | 4·72 | 1·18 | 5·77 | 1·19 | 4·75 | ·87 | 4·4 |
| September ... | 2·75 | ·53 | 2·53 | ·56 | 2·30 | ·30 | 3·19 | ·62 | 2·98 | ·36 | 2·24 | ·3 |
| October ..... | 1·19 | 5·60 | 1·14 | 6·20 | 1·04 | 6·27 | 1·32 | 6·76 | 1·82 | 6·22 | 1·04 | 6·4 |
| November ... | 2·27 | 2·39 | 2·18 | 1·97 | 2·26 | 2·25 | 2·09 | 2·32 | 2·10 | 2·55 | 2·12 | 2·3 |
| December ... | ·43 | ·76 | ·68 | 1·36 | ·60 | 1·06 | ·76 | 1·23 | ·71 | 1·05 | ·72 | 1·1 |
| Totals ..... | 16·69 | 25·89 | 17·02 | 29·44 | 16·56 | 29·24 | 19·02 | 31·39 | 18·95 | 29·00 | 15·44 | 26·7 |

### Division II.—SOUTH-EASTERN COUNTIES (*continued*).

| SURREY (*continued*). | | KENT. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Height of Rain-gauge above Ground ..... Sea-level..... | Wandsworth S. Fields. 1 ft. 0 in. ..... | Dover. 2 ft 2 in. 16 ft. | | Horton Park, Hythe. 1 ft. 6 in. 350 ft. | | Linton Park, Staplehurst. 0 ft. 6 in. 300 ft. | | Tunbridge. 1 ft. 0 in. 125 ft. | | River Hil Sevenoak 9 ft. 0 in. 530 ft. | |
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 18 |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| January ..... | ·87 | 3·30 | ·68 | 5·49 | 1·11 | 4·15 | ·77 | 4·48 | ·74 | 3·80 | ·76 | 3 |
| February ... | ·85 | 1·88 | 1·97 | 2·61 | 2·27 | 3·05 | 1·36 | 2·49 | 1·16 | 2·13 | ·97 | 2 |
| March ..... | 2·70 | ·95 | 2·66 | 2·27 | 2·57 | 3·63 | 3·06 | 2·14 | 3·42 | 1·91 | 3·11 | 1 |
| April ..... | 1·00 | ·27 | ·61 | ·24 | ·46 | ·36 | ·59 | ·38 | ·88 | ·36 | ·82 | |
| May ..... | 2·00 | 3·00 | 2·18 | 2·53 | 2·15 | 3·42 | 2·35 | 2·89 | 1·76 | 3·64 | 1·64 | 3 |
| June ..... | 1·35 | 2·25 | 1·91 | 1·46 | 2·48 | 1·03 | 1·24 | 1·17 | 1·22 | 1·19 | 1·15 | 1 |
| July ..... | ·55 | 2·60 | ·32 | 4·35 | ·71 | 3·55 | ·63 | 3·48 | ·51 | 4·48 | ·56 | 3 |
| August ..... | 2·58 | 4·38 | 1·69 | 3·76 | 1·59 | 3·97 | 1·63 | 5·26 | 1·18 | 4·84 | 1·26 | 4 |
| September ... | 1·57 | ·57 | 2·44 | ·15 | 2·96 | ·54 | 2·51 | ·08 | 3·21 | ·02 | 2·51 | |
| October ..... | 1·25 | 6·13 | 1·62 | 9·23 | 1·22 | 9·79 | 1·47 | 8·14 | 1·63 | 7·86 | ·85 | 6 |
| November ... | 2·65 | 2·55 | 5·96 | 4·58 | 5·29 | 4·88 | 4·50 | 2·74 | 4·65 | 2·78 | 3·78 | 2 |
| December ... | ·38 | 1·35 | 1·00 | 1·36 | ·92 | 1·62 | 1·14 | 1·93 | 1·05 | 1·74 | 1·01 | 1 |
| ..... | 17·75 | 29·23 | 23·04 | 38·03 | 23·73 | 39·99 | 21·25 | 35·18 | 21·41 | 34·75 | 18·42 | 29 |

## ENGLAND AND WALES.

### Division X.—Northern Counties (*continued*).

| Northumberland (*continued*). | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bywell. | | Wylam. | | North Shields. | | Deadwater. | | Park End, Hexham. | | Roddam. | | Lilburn Tower. | |
| ft. 6 in.<br>87 ft. | | 0 ft. 4 in.<br>96 ft. | | 1 ft. 0 in.<br>124 ft. | | ……<br>…… | | 0 ft. 4 in.<br>277 ft. | | 0 ft. 6 in.<br>545 ft. | | 6 ft. 0 in.<br>290 ft. | |
| 64. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| . | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| ·38 | 1·68 | ·76 | 1·21 | ·99 | 1·76 | 4·20 | 3·20 | 3·52 | 1·86 | 1·58 | 3·05 | ·90 | 2·10 |
| ·57 | 1·72 | 1·96 | 1·50 | 2·49 | 1·47 | 2·30 | 2·70 | 3·37 | 4·50 | 4·03 | 1·94 | 2·41 | 1·05 |
| ·50 | 1·79 | 3·79 | 1·54 | 3·49 | 1·54 | 3·20 | 2·20 | 3·16 | 1·26 | 4·62 | 1·53 | 2·58 | 1·26 |
| ·05 | 1·32 | 1·04 | 1·24 | 1·69 | 1·56 | 2·00 | 1·00 | ·90 | ·79 | ·66 | ·99 | ·91 | ·85 |
| ·08 | 4·91 | 2·73 | 4·56 | 2·59 | 4·11 | 2·00 | 7·00 | 2·04 | 3·51 | 3·02 | 1·67 | 3·06 | 4·93 |
| 1·36 | ·47 | 1·16 | ·63 | 1·94 | ·65 | 3·00 | 1·00 | 1·92 | ·52 | ·99 | 1·21 | ·87 | ·59 |
| ·58 | 2·32 | ·67 | 2·56 | ·91 | 1·93 | 2·80 | 3·00 | ·68 | 3·65 | 1·26 | 3·30 | 1·32 | 2·87 |
| 1·14 | 3·64 | 1·58 | 2·86 | 1·14 | 2·82 | 2·00 | 3 20 | 1·08 | 3·08 | ·97 | 1·75 | ·92 | 2·60 |
| 2·13 | ·24 | 1·99 | ·32 | 1·97 | ·56 | 5·00 | 1·00 | 2·88 | ·50 | 2·79 | ·07 | 2·62 | ·23 |
| 7·50 | 7·49 | 6·67 | 9·51 | 4·60 | 6·61 | 6·20 | 6·00 | 4·53 | 5·24 | 8·56 | 10·43 | 10·58 | 8·47 |
| 2·26 | 2·49 | 2·17 | 2·74 | 2·38 | 2·36 | 5·00 | 4·20 | 1·41 | 3·36 | 3·44 | 3·55 | 3·04 | 4·08 |
| 2·37 | 1·75 | 3·05 | 1·00 | 2·58 | 1·53 | 5·10 | 5·10 | 3·53 | 1·53 | 3·96 | 2·23 | 2·76 | 1·36 |
| 8·77 | 29·82 | 27·57 | 29·67 | 26·77 | 26·90 | 42·80 | 39·60 | 29·02 | 29·80 | 35·88 | 31·72 | 31·97 | 30·39 |

### Division X.—Northern Counties (*continued*).

| Cumberland (*continued*). | | | | Westmoreland. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Silloth. | | Scaleby. | | Kendal. | | Lesketh How. | | The How, Troutbeck. | | Edenhall, Penrith. | | Appleby. | |
| 3 ft. 0 in.<br>28 ft. | | 0 ft. 8 in.<br>…… | | 4 ft. 6 in.<br>149 ft. | | 3 ft. 0 in.<br>200 ft. | | 1 ft. 2 in.<br>470 ft. | | ……<br>…… | | 1 ft. 0 in.<br>442 ft. | |
| 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| in. | in. | in. | in. | in. | in. | in. | in: | in. | in. | in. | in. | in. | in. |
| 2·35 | 2·55 | 2·31 | 1·98 | 5·17 | 4·60 | 9·95 | 8·25 | 10·96 | 7·48 | 2·10 | 2·05 | 2·92 | 1·89 |
| 1·77 | 2·63 | 2·04 | 2·92 | 3·97 | 4·80 | 5·73 | 7·00 | 7·14 | 7·57 | 1·65 | 1·95 | 2·22 | 2·52 |
| 2·75 | 1·44 | 2·30 | ·50 | 3·73 | 1·79 | 6·97 | 2·99 | 7·99 | 3·43 | 2·67 | ·65 | 1·99 | 1·60 |
| 1·66 | ·38 | 1·54 | ·65 | 2·26 | 1·21 | 2·99 | 1·80 | 4·01 | 1·51 | 1·55 | ·90 | 1·37 | ·85 |
| 1·91 | 4·84 | 2·38 | 5·39 | 1·86 | 6·56 | 2·52 | 8·65 | 2·44 | 8·14 | 1·83 | 5·20 | 2·22 | 5·58 |
| 2·91 | ·97 | 1·98 | 1·22 | 3·63 | ·56 | 4·69 | ·65 | 5·25 | ·54 | 2·37 | ·94 | 2·72 | ·76 |
| 1·65 | 2·03 | 1·31 | 1·86 | 3·31 | 1·96 | 3·65 | 3·39 | 3·84 | 3·37 | 1·02 | 2·25 | 1·25 | 1·21 |
| 1·80 | 3·15 | 1·90 | 4·24 | 3·55 | 7·10 | 5·21 | 8·12 | 4·80 | 7·38 | 1·75 | 4·10 | 1·74 | 3·85 |
| 5·15 | 1·32 | 4·37 | ·70 | 6·12 | 1·78 | 9·39 | 2·78 | 8·47 | 2·33 | 3·73 | ·85 | 4·20 | ·44 |
| 4·78 | 3·64 | 3·03 | 4·70 | 3·04 | 5·20 | 3·95 | 7·74 | 2·99 | 8·49 | 4·05 | 4·60 | 2·37 | 4·73 |
| 2·05 | 3·00 | 1·47 | 2·52 | 3·81 | 4·27 | 7·47 | 7·14 | 6·65 | 7·99 | 3·27 | 3·00 | 2·46 | 2·89 |
| 4·79 | 2·79 | 2·64 | 2·15 | 7·12 | 2·84 | 11·57 | 7·29 | 11·20 | 5·82 | 2·62 | 2·50 | 3·39 | 3·94 |
| 31·57 | 28·74 | 27·27 | 28·83 | 47·57 | 42·67 | 74·09 | 65·80 | 75·74 | 64·05 | 28·61 | 28·99 | 28·35 | 30·26 |

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## ENGLAND AND WALES.

### Division II.—South-Eastern Counties (*continued*).

| Height of Rain-gauge above Ground / Sea-level | West Sussex (*continued*): Dale Park, Arundel. 4 ft. 0 in. / 316 ft. | | Battle. 1 ft. 3 in. / ..... | | Chilgrove, Chichester. 0 ft. 6 in. / 284 ft. | | Hurstpierpoint. 0 ft. 8 in. / 120 ft. | | Petworth Rectory. 2 ft. 4 in. / ..... | | East Sussex: Uckfield. 6 ft. 0 in. / 149 ft. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| January | 2·11 | 4·29 | 1·30 | 5·10 | 2·06 | 4·35 | 1·51 | 4·31 | 1·55 | 4·95 | ·94 | 5·26 |
| February | ·41 | 3·36 | 2·50 | 3·21 | 1·48 | 2·60 | ·92 | 2·77 | 1·40 | 2·34 | 1·03 | 1·63 |
| March | 3·43 | 1·45 | 2·68 | 2·14 | 3·39 | 1·26 | 3·34 | 1·31 | 2·84 | 1·23 | 3·64 | 1·82 |
| April | 1·02 | ·28 | 1·04 | ·26 | 1·48 | ·43 | ·81 | ·38 | 1·50 | ·22 | 1·04 | ·33 |
| May | 1·31 | 2·72 | 2·43 | 3·87 | 1·60 | 2·89 | 1·34 | 3·05 | 1·88 | 3·36 | 1·94 | 3·37 |
| June | ·82 | 1·74 | 1·48 | 1·44 | 1·33 | 2·27 | 1·03 | ·87 | 1·40 | 1·10 | 1·01 | 1·35 |
| July | ·05 | 3·73 | ·88 | 2·94 | ·38 | 2·44 | ·42 | 3·48 | ·33 | 2·46 | ·46 | 4·16 |
| August | 1·33 | 5·28 | 2·24 | 3·33 | 1·04 | 5·49 | 1·80 | 3·97 | 1·36 | 5·02 | 1·73 | 3·76 |
| September | 3·70 | ·12 | 4·00 | ·09 | 4·26 | ·30 | 3·24 | ·22 | 3·31 | ·16 | 3·06 | ·02 |
| October | 1·63 | 12·23 | 2·15 | 11·88 | 1·88 | 9·95 | 2·58 | 10·59 | 1·50 | 10·19 | 2·09 | 11·23 |
| November | 3·61 | 3·86 | 6·28 | 3·16 | 4·35 | 3·50 | 5·03 | 3·48 | 4·67 | 4·43 | 5·56 | 3·06 |
| December | 1·29 | 3·20 | 1·32 | 2·18 | 1·42 | 2·97 | 1·37 | 1·93 | 1·28 | 3·37 | ·98 | 2·28 |
| Totals | 20·71 | 42·26 | 28·30 | 39·60 | 24·67 | 38·45 | 23·39 | 36·36 | 23·02 | 38·83 | 23·48 | 38·97 |

### Div. II.—South-Eastern Counties (*continued*). Div. III.—South Midland Counties

| Height of Rain-gauge above Ground / Sea-level | Hampshire (*continued*): Aldershot. 3 ft. 0 in. / 325 ft. | | Berkshire: Royal Military College, Sandhurst. 5 ft. 6 in. / 246 ft. | | Long Wittenham. 1 ft. 0 in. / 170 ft. | | Hertfordshire: Watford House. 1 ft. 6 in. / 190 ft. | | Berkhampstead. 1 ft. 6 in. / 370 ft. | | Royston. 0 ft. 6 in. / 266 ft. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| January | ·92 | 3·64 | 1·61 | 2·77 | 1·06 | 3·48 | 1·01 | 1·72 | 1·30 | 3·85 | 1·09 | 3·11 |
| February | 1·23 | 2·68 | ·83 | 1·65 | 1·17 | 2·45 | ·97 | 2·81 | 1·04 | 2·55 | ·72 | 2·14 |
| March | 2·94 | ·70 | 2·46 | ·78 | 3·23 | 1·02 | 2·65 | 1·10 | 3·11 | 1·39 | 3·75 | 1·13 |
| April | 1·64 | ·71 | 1·42 | ·52 | 1·71 | ·93 | 1·10 | ·33 | 1·46 | ·49 | ·71 | ·36 |
| May | 1·62 | 1·84 | 1·52 | 1·81 | 1·60 | 3·14 | 1·89 | 2·61 | 2·47 | 1·83 | 2·28 | 1·61 |
| June | ·92 | 2·62 | ·90 | 2·51 | 1·76 | 3·36 | 2·44 | 2·11 | 1·62 | 2·49 | 1·26 | 2·11 |
| July | ·34 | 1·60 | ·40 | 2·06 | ·44 | 2·19 | ·99 | 3·97 | ·29 | 3·01 | ·38 | 3·54 |
| August | ·81 | 3·91 | 1·04 | 2·92 | ·93 | 2·85 | ·59 | 3·59 | ·68 | 3·69 | ·36 | 3·40 |
| September | 3·25 | ·54 | 1·98 | ·27 | 2·09 | ·19 | 2·74 | ·48 | 2·73 | ·51 | 1·96 | ·17 |
| October | 1·58 | 5·80 | 1·43 | 4·72 | 1·22 | 6·40 | 1·10 | 6·20 | 1·63 | 6·55 | 1·32 | 6·13 |
| November | 2·52 | 3·54 | 2·44 | 2·95 | 2·23 | 2·71 | 2·26 | 2·28 | 3·04 | 2·93 | 2·36 | 1·81 |
| December | ·84 | 2·04 | ·35 | 1·41 | ·87 | 1·63 | ·66 | 2·39 | ·45 | 2·41 | ·42 | 1·19 |
| ..... | 18·61 | 29·62 | 15·38 | 24·37 | 18·31 | 30·35 | 18·40 | 29·59 | 19·82 | 31·70 | 16·67 | 29·77 |

# ENGLAND AND WALES.

## Division II.—South-Eastern Counties (*continued*).

### Hampshire.

| Ventnor, Isle of Wight. | | Ryde, Isle of Wight. | | Osborne, Isle of Wight. | | Fareham. | | Southampton, Ordnance Survey Office. | | The Wakes, Selborne. | | Liss, Petersfield. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *3 ft. 0 in.* *150 ft.* | | 7 ft. 0 in. 15 ft. | | 3 ft. 0 in. 172 ft. | | 0 ft. 0 in. 26 ft. | | 1 ft. 3 in. 75 ft. | | 4 ft. 0 in. 500 ft. | | 0 ft. 6 in. ..... | |
| 864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| n. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| ·79 | 5·74 | 2·35 | 4·98 | 1·70 | 4·48 | 2·84 | 4·09 | 2·85 | 5·05 | 1·97 | 3·86 | 1·92 | 4·10 |
| ·55 | 2·48 | 1·55 | 3·22 | 1·43 | 2·51 | 1·18 | 3·50 | 2·11 | 4·08 | 1·58 | 3·11 | 1·65 | 3·17 |
| 4·26 | 1·29 | 3·77 | 1·10 | 3·30 | ·97 | 3·52 | 1·01 | 3·31 | 1·10 | 3·69 | 1·18 | 3·87 | 1·24 |
| ·34 | ·59 | 1·70 | ·62 | 1·73 | ·67 | 2·86 | 1·30 | 2·46 | ·86 | 1·86 | ·89 | 2·11 | ·68 |
| ·31 | 1·86 | 1·41 | 2·74 | 1·40 | 2·52 | 1·20 | 3·46 | 1·55 | 2·92 | 1·56 | 2·44 | 1·49 | 2·92 |
| ·25 | 2·30 | 1·58 | 2·42 | 1·30 | 2·36 | ·86 | 1·36 | 1·41 | 2·56 | 1·13 | 2·35 | 1·14 | 3·50 |
| ·38 | 1·36 | ·24 | 2·01 | ·15 | 2·54 | ·28 | 5·07 | ·32 | 4·07 | ·36 | 2·77 | ·32 | 2·64 |
| ·42 | 2·44 | 1·00 | 3·97 | ·96 | 3·28 | ·53 | 4·71 | ·81 | 5·06 | 1·07 | 5·01 | 1·05 | 5·37 |
| 2·41 | ·14 | 2·85 | ·21 | 4·10 | ·04 | 4·40 | ·25 | 2·43 | ·13 | 3·02 | ·20 | 3·96 | ·13 |
| 1·17 | 9·14 | 1·72 | 11·10 | 1·27 | 8·10 | 2·10 | 6·89 | 1·42 | 8·74 | 2·03 | 7·95 | 1·93 | 10·30 |
| 4·49 | 3·18 | 4·12 | 3·59 | 3·92 | 3·79 | 3·18 | 4·81 | 4·27 | 4·82 | 4·20 | 4·83 | 4·41 | 5·07 |
| 1·15 | 2·51 | 1·58 | 3·24 | 1·41 | 3·70 | 1·80 | 2·66 | 2·32 | 3·32 | 1·24 | 3·59 | 1·37 | 3·69 |
| 2·87 | 32·73 | 23·87 | 39·20 | 22·67 | 34·96 | 24·75 | 39·11 | 25·26 | 42·71 | 23·71 | 38·18 | 25·22 | 42·81 |

## Division III.—South Midland Counties (*continued*).

| Hertford-shire (*cont.*). | | Oxford. | | | | Northampton. | | | | Bedford. | | Cambridge. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hitchin. | | Radcliffe Observatory. | | Banbury. | | Althorpe House. | | Welling-borough. | | Bedford. | | Wisbech Observatory. | |
| ft. 0 in. 240 ft. | | 0 ft. 8 in. 210 ft. | | 7 ft. 0 in. 345 ft. | | 3 ft. 0 in. 310 ft. | | 0 ft. 2 in. ..... | | 3 ft. 0 in. 104 ft. | | 8 ft. 0 in. 18 ft. | |
| 864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| . | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| ·06 | 2·96 | ·97 | 3·05 | ·94 | 2·51 | ·95 | 2·52 | ·91 | 3·52 | ·95 | 2·62 | ·66 | 2·53 |
| ·56 | 2·38 | 1·44 | 1·87 | 1·44 | 2·35 | 1·45 | 1·88 | ·72 | 4·71 | ·55 | 2·25 | 1·27 | 3·77 |
| ·14 | 1·22 | 2·47 | ·97 | 2·95 | 1·02 | 2·69 | 1·07 | 3·57 | 1·20 | 4·03 | 1·22 | 2·74 | 1·17 |
| ·94 | ·64 | 1·63 | ·91 | 1·37 | ·78 | 1·52 | ·97 | 1·34 | 1·23 | 1·08 | ·64 | ·62 | ·5· |
| ·06 | 1·42 | 2·15 | 2·19 | 2·51 | 1·50 | 1·65 | 1·44 | 1·51 | 1·88 | 1·88 | 1·61 | 1·69 | 1·6. |
| 30 | 1·76 | 1·01 | 3·52 | 1·50 | 3·69 | ·93 | 3·16 | 1·06 | 2·36 | ·94 | 1·91 | 1·13 | 1·56 |
| ·17 | 4·77 | ·47 | 2·80 | ·88 | 3·66 | ·66 | 3·59 | ·76 | 3·67 | ·89 | 2·86 | ·54 | 4·37 |
| ·63 | 4·28 | ·79 | 3·09 | ·67 | 3·79 | ·73 | 3·55 | ·49 | 3·80 | ·39 | 3·88 | ·85 | 4·26 |
| ·15 | ·59 | 2·94 | ·18 | 2·06 | ·29 | 2·53 | ·18 | 2·05 | ·41 | 1·61 | ·57 | 1·90 | ·37 |
| ·35 | 7·07 | 1·56 | 5·41 | 2·10 | 4·56 | 1·45 | 3·72 | 1·72 | 4·54 | 1·06 | 5·02 | ·84 | 5·42 |
| ·03 | 2·16 | 2·32 | 2·58 | 2·10 | 2·52 | 1·93 | 2·11 | 1·74 | 2·03 | 1·60 | 1·51 | 2·13 | 1·75 |
| ·77 | 1·01 | ·51 | 1·96 | 1·70 | 1·62 | ·72 | 1·31 | 1·01 | 1·31 | ·75 | ·69 | 1·04 | 1·16 |
| ·16 | 30·26 | 18·26 | 28·53 | 20·22 | 28·29 | 17·21 | 25·50 | 16·88 | 30·66 | 15·73 | 24·78 | 15·41 | 26·52 |

ENGLAND & WALES. SCOTLAND.

| Div. XI.—(*continued*). | Division XII.—Southern Counties. | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Channel Islands (*continued*). | Wigton. | | Kirkcudbright. | | | | | | | | Dumfries. | |
| Height of Rain-gauge above Ground ..... Sea-level..... | Alderney. 10 ft. 0 in. 48 ft. | | Stranraer, S. Cairn. 0 ft. 4 in. 209 ft. | | Little Ross. 3 ft. 3 in. 130 ft. | | CastleDouglas, Slogarie. 0 ft. 6 in. 800 ft. | | Cargen. 0 ft. 3 in. 80 ft. | | Drumlanrig 0 ft. 4 in. 191 ft. | |
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| January ..... | 1·27 | 3·59 | 4·70 | 4·30 | 1·50 | 1·94 | 8·51 | 7·00 | 3.78 | 4·12 | 4·60 | 4·0 |
| February ... | 1·66 | 2·22 | 3·35 | 4·15 | 1·26 | 3·05 | 3·48 | 4·50 | 2·77 | 2·96 | 3·00 | 2·7 |
| March ..... | 2·82 | 1·68 | 5·65 | 3·20 | 3·92 | ·86 | 6·51 | 2·79 | 3·88 | 1·49 | 4·00 | 2·1 |
| April ..... | ·58 | 1·76 | 3·20 | ·80 | 1·96 | ·44 | 2·78 | ·80 | 1·40 | ·71 | 2·10 | · |
| May ..... | 1·02 | 1·86 | 1·65 | 4·55 | 1·25 | 2·94 | 2·29 | 7·14 | 1·42 | 6·66 | 1·30 | 6·7 |
| June ..... | ·76 | 2·68 | 3·30 | 1·20 | 1·14 | ·61 | 4·79 | ·80 | 3·41 | ·52 | 3·20 | · |
| July ..... | ·43 | 1·52 | 3·15 | 3·65 | ·78 | 1·59 | 2·94 | 4·75 | 2·29 | 2·75 | 2·30 | 2·7 |
| August ..... | 1·62 | 1·95 | 2·60 | 3·60 | 1·27 | 1·84 | 3·17 | 5·84 | 1·44 | 4·98 | 1·10 | 5·3 |
| September ... | 6·81 | ·02 | 5·40 | ·65 | 3·77 | ·73 | 8·50 | 2·20 | 6·21 | 1·18 | 7·00 | ·9 |
| October ..... | ·86 | 7·34 | 2·75 | 5·40 | 3·34 | 5·49 | 5·17 | 6·45 | 4·92 | 5·96 | 4·20 | 3·3 |
| November ... | 4·12 | 3·69 | 4·20 | 6·20 | 3·12 | 3·02 | 7·87 | 7·32 | 4·70 | 4·78 | 4·60 | 3·8 |
| December ... | 2·61 | 2·26 | 2·50 | 3·60 | 3·28 | 2·73 | 9·94 | 8·19 | 3·90 | 5·08 | 4·60 | 6·4 |
| Totals ..... | 20·56 | 30·57 | 42·45 | 41·30 | 26·59 | 25·24 | 65·95 | 57·78 | 40·12 | 41·19 | 42·00 | 39·5 |

| Div. XIII.—Southern Counties *cont.* | Div. XIV.—South-Western Counties. | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Edinburgh (*continued*). | Lanark. | | | | | | | | | | | |
| Height of Rain-gauge above Ground ..... Sea-level..... | Invereek. 2 ft. 0 in. 60 ft. | | Edinburgh, Charlotte-sq. 0 ft. 6 in. 230 ft. | | Douglas Castle Newmains. 0 ft. 2 in. 783 ft. | | Auchinraith. 4 ft. 2 in. 150 ft. | | Glasgow Observatory. 0 ft. 3 in. 200 ft. | | Bailliestor. 0 ft. 3 in. 230 ft. | |
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| January ..... | 1·19 | 3·20 | 1·25 | 2·29 | 5·80 | 6·75 | 2·05 | 1·62 | 3·65 | 4·26 | 3·32 | 3·6 |
| February ... | 2·36 | 1·09 | 2·14 | 1·70 | 4·42 | 3·82 | 2·15 | 1·55 | 3·93 | 1·79 | 3·92 | 2·9 |
| March ..... | 2·66 | 1·06 | 3·10 | ·99 | 6·75 | 2·06 | 3·65 | 1·40 | 4·09 | 2·06 | 4·91 | 1·6 |
| April ..... | 1·21 | ·58 | 1·16 | ·30 | 2·05 | ·56 | 1·45 | ·35 | 2·23 | ·85 | 1·99 | 1·1 |
| May ..... | 2·31 | 4·55 | 2·13 | 3·65 | 1·69 | 5·37 | 1·35 | 3·60 | 1·51 | 3·51 | 1·72 | 5·3 |
| June ..... | 2·17 | ·32 | 1·20 | ·41 | 3·95 | ·37 | 1·85 | ·45 | 3·37 | ·64 | 2·99 | ·8 |
| July ..... | 1·61 | 3·25 | 2·15 | 3·20 | 2·97 | 3·30 | 2·70 | 2·36 | 3·25 | 2·40 | 4·07 | 3·5 |
| August ..... | ·95 | 4·55 | ·80 | 3·41 | 1·20 | 4·30 | ·95 | 4·30 | 1·89 | 5·93 | 1·33 | 7·0 |
| September ... | 3·44 | ·60 | 3·40 | ·55 | 2·42 | ·44 | 3·85 | ·63 | 4·20 | 1·27 | 5·63 | 1·2 |
| October ..... | 8·06 | 4·99 | 6·90 | 3·96 | 4·83 | 2·58 | 3·55 | 3·38 | 3·17 | 4·69 | 5·72 | 4·3 |
| November ... | 2·27 | 2·26 | 1·79 | 1·60 | 5·02 | 3·13 | 2·20 | 2·34 | 3·19 | 3·43 | 3·31 | 3·3 |
| December ... | 1·79 | 1·33 | 2·07 | 1·59 | 3·78 | 3·74 | 1·60 | 2·30 | 2·67 | 4·54 | 2·80 | 3·3 |
| .. | 30·02 | 27·78 | 28·09 | 23·65 | 44·88 | 36·42 | 27·35 | 24·28 | 37·15 | 35·37 | 41·71 | 38·0 |

## SCOTLAND.

### Division XIII.—South-Eastern Counties.

| XII.—…N. (co). | | Selkirk. | | Peebles. | | Berwick. | | Haddington. | | | | Edinburgh. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| …MYRIES …tinued). | | Selkirk Bowhill. | | Penicuick N. Esk Reservoir. | | Thirlestane Castle. | | Yester. | | East Linton. | | Glencorse. | |
| …ockhead. | | 4 ft. 0 in. 537 ft. | | 0 ft. 6 in. 1150 ft. | | 0 ft. 3 in. 558 ft. | | 1 ft. 0 in. 420 ft. | | 0 ft. 3 in. 90 ft. | | 0 ft. 6 in. 787 ft. | |
| …4 in. 530 ft. | | | | | | | | | | | | | |
| …. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| …11 | 5·36 | 1·58 | 2·77 | 2·40 | 5·25 | 2·00 | 1·90 | 1·45 | 3·60 | ·91 | 2·15 | 2·20 | 3·65 |
| …46 | 3·84 | 1·73 | 1·57 | 2·55 | 1·60 | 2·45 | 2·30 | 2·30 | 1·40 | 2·43 | ·56 | 3·10 | 1·75 |
| …77 | 2·97 | 3·33 | 1·45 | 4·40 | 1·20 | 3·50 | 1·30 | 2·25 | 1·25 | 3·16 | ·81 | 4·05 | 1·55 |
| 97 | ·72 | ·77 | ·63 | 1·05 | ·45 | ·80 | ·90 | ·85 | 1·25 | ·70 | ·78 | ·90 | ·40 |
| …12 | 6·45 | 2·35 | 3·17 | 1·90 | 4·30 | 2·60 | 3·20 | 2·15 | 5·15 | 1·90 | 5·27 | 1·90 | 6·05 |
| ·69 | ·60 | 2·10 | 1·10 | 2·45 | ·70 | 1·10 | ·10 | ·95 | 1·85 | 1·43 | ·25 | 1·45 | ·40 |
| …79 | 2·00 | 1·30 | 2·13 | 2·30 | 4·25 | 1·70 | 2·10 | ·90 | 2·70 | 1·82 | 3·07 | 2·20 | 3·40 |
| …14 | 8·38 | ·88 | 3·13 | 1·05 | 4·65 | 1·00 | 3·90 | 1·60 | 3·10 | 1·18 | 2·28 | ·65 | 4·50 |
| 9·18 | 1·46 | 3·49 | ·45 | 3·98 | 1·00 | 3·85 | ·90 | 2·90 | 1·25 | 2·48 | ·65 | 3·60 | ·70 |
| 4·15 | 4·74 | 5·25 | 5·90 | 7·95 | 7·60 | 6·85 | 7·70 | 11·60 | 9·05 | 10·43 | 5·89 | 9·90 | 6·55 |
| 5·43 | 5·93 | 3·26 | 3·33 | 2·95 | 3·10 | 3·20 | 2·20 | 4·05 | 2·90 | 1·95 | 1·20 | 3·20 | 2·95 |
| 3·86 | 10·42 | 2·78 | 3·06 | 3·00 | 2·60 | 2·70 | 2·30 | 3·15 | 2·60 | 1·53 | ·96 | 2·65 | 2·70 |
| 3·67 | 52·87 | 28·82 | 28·69 | 35·98 | 36·70 | 31·75 | 28·80 | 34·15 | 36·10 | 29·92 | 23·87 | 35·80 | 34·60 |

### Division XIV.—South-Western Counties (*continued*).

| Lanark (continued). | | Ayr. | | | | | | Renfrew. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| …hotts, Hill …nd House. | | Girvan. | | Ayr, Achendrane House. | | Mansfield, Largs. | | Nither Place, Mearns. | | Paisley Stanley Reservoir. | | Greenock. | |
| …7 ft. 0 in. 620 ft. | | 0 ft. 6 in. 15 ft. | | 2 ft. 3 in. 94 ft. | | 0 ft. 6 in. 30 ft. | | 0 ft. 5 in. 350 ft. | | ..... 100 ft. | | 0 ft. 6 in. 50 ft. | |
| 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| 2·37 | 1·55 | 4·50 | 6·70 | 2·40 | 3·74 | 4·20 | 5·20 | 5·50 | 3·75 | 4·10 | 4·40 | 6·37 | 6·80 |
| 2·52 | ·53 | 2·50 | 3·50 | 2·65 | 2·73 | 4·20 | 3·00 | 4·38 | 2·75 | 3·60 | 3·38 | 5·77 | 4·40 |
| 3·80 | ·91 | 7·20 | 2·80 | 4·95 | 2·20 | 3·90 | 2·40 | 8·12 | 2·38 | 5·60 | 2·07 | 6·37 | 2·83 |
| 1·21 | ·64 | 2·60 | ·50 | 2·05 | ·67 | 3·30 | ·70 | 2·13 | 1·12 | 2·60 | ·57 | 3·00 | 1·30 |
| 1·40 | 3·04 | 1·40 | 4·20 | 2·03 | 4·06 | 2·20 | 2·70 | 1·00 | 3·00 | 1·20 | 3·60 | 1·93 | 3·88 |
| 2·62 | ·59 | 3·50 | 1·20 | 2·33 | 1·28 | 2·90 | 1·00 | 4·50 | 1·13 | 3·30 | ·65 | 4·23 | ·95 |
| 3·02 | 2·67 | 3·00 | 2·50 | 2·32 | 1·91 | 3·00 | 2·80 | 3·00 | 2·25 | 2·70 | 2·68 | 3·33 | 2·64 |
| 1·58 | 4·58 | 2·10 | 4·30 | 1·80 | 4·82 | 2·30 | 7·20 | 2·50 | 5·50 | 1·40 | 4·35 | 1·97 | 6·77 |
| 4·24 | 1·06 | 5·00 | 1·10 | 5·80 | 1·16 | 5·60 | 1·90 | 6·25 | 2·00 | 5·50 | 1·23 | 7·60 | 1·70 |
| 4·92 | 4·10 | 3·20 | 5·10 | 3·24 | 3·10 | 2·60 | 4·70 | 5·62 | 5·12 | 3·50 | 4·60 | 2·93 | 6·40 |
| 2·23 | 2·61 | 5·50 | 4·96 | 4·02 | 2·88 | 5·50 | 3·60 | 4·25 | 4·13 | 3·20 | 4·10 | 6·83 | 4·65 |
| 2·19 | 1·90 | 2·85 | 4·80 | 3·22 | 2·51 | 3·10 | 4·60 | 4·50 | 5·25 | 3·10 | 5·00 | 5·47 | 7·11 |
| 32·10 | 24·18 | 43·35 | 41·66 | 36·80 | 31·06 | 42·80 | 39·80 | 51·75 | 38·38 | 39·80 | 36·63 | 55·80 | 49·43 |

## ENGLAND AND WALES.

### Division V.—South-Western Counties (*continued*).

| Height of Rain-gauge above Ground ..... Sea-level..... | Devonshire (*continued*). Castle Hill, South Molton. 3 ft. 0 in. 150 ft. | | Great Torrington. 3 ft. 10 in. 450 ft. | | Barnstaple. 0 ft. 6 in. 31 ft. | | Cornwall. Helston. 5 ft. 0 in. 115 ft. | | Penzance. 3 ft. 0 in. 94 ft. | | Tehidy Pa Redruth 0 ft. 0 i 100 ft. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 18 |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| January ..... | 1·84 | 5·50 | 2·12 | 5·58 | 1·74 | 4·95 | 2·70 | 6·02 | 3·36 | 6·90 | 3·80 | 5· |
| February ... | 1·95 | 4·37 | 2·23 | 3·13 | 2·15 | 3·98 | 2·37 | 4·63 | 1·66 | 5·63 | 1·82 | 3· |
| March ..... | 3·14 | 3·57 | 2·62 | 3·33 | 2·56 | 2·99 | 2·64 | 2·39 | 2·63 | 2·84 | 2·30 | 2· |
| April ..... | 2·23 | 1·01 | 1·53 | 1·43 | 2·04 | 1·45 | 1·57 | 1·44 | 1·28 | 1·03 | 1·35 | 1· |
| May ..... | 1·58 | 4·09 | ·81 | 3·73 | 1·35 | 3·18 | 1·46 | 2·34 | 1·33 | 3·12 | 1·60 | 3· |
| June ..... | 3·82 | 2·10 | 3·47 | 1·33 | 3·03 | 2·26 | 1·59 | 1·93 | 1·76 | 1·42 | 1·60 | · |
| July ..... | 1·27 | 4·63 | 1·17 | 3·14 | ·89 | 3·02 | ·77 | 4·09 | ·77 | 3·29 | 1·05 | 4· |
| August ..... | 2·50 | 6·77 | 1·52 | 5·02 | 2·11 | 4·52 | ·50 | 5·64 | 1·25 | 4·35 | 1·12 | 3· |
| September ... | 5·51 | ·44 | 4·32 | ·10 | 4·29 | ·26 | 3·33 | ·05 | 4·03 | ·10 | 3·33 | |
| October ..... | 2·73 | 5·68 | 3·77 | 5·39 | ·64 | 5·57 | 3·32 | 7·75 | 2·67 | 8·21 | 3·70 | 5· |
| November ... | 4·51 | 5·17 | 4·17 | 4·44 | 3·54 | 4·04 | 3·90 | 4·93 | 5·15 | 5·89 | 3·40 | 4· |
| December ... | 2·47 | 3·16 | 3·15 | 3·74 | 2·09 | 3·14 | 4·41 | 3·53 | 3·94 | 4·80 | 4·20 | 4· |
| Totals ..... | 33·55 | 46·49 | 30·88 | 40·36 | 26·43 | 39·36 | 28·56 | 44·74 | 29·83 | 47·58 | 29·27 | 5· |

### Div. V.—S.W. Counties (*continued*). Division VI.—West Midland Counties.

| Height of Rain-gauge above Ground ..... Sea-level..... | Somerset (*continued*). Batheaston. 2 ft. 0 in. 226 ft. | | Gloucester. Bristol, Park-row. 6 ft. 0 in. 140 ft. | | Clifton. 0 ft. 6 in. 192 ft. | | Cirencester. 1 ft. 2 in. 446 ft. | | The Spa, Gloucester. 3 ft. 6 in. 50 ft. | | Shropshi Haugh: Hall, Shif 4 ft. 6 i 450 ft | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 18 |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| January ..... | 1·30 | 2·67 | 1·66 | 3·21 | 1·56 | 3·76 | 1·82 | 4·21 | 1·12 | 2·17 | ·73 | · |
| February ... | 1·22 | 1·51 | 1·74 | 2·96 | 1·88 | 2·88 | 1·93 | 2·50 | 1·27 | 1·62 | 1·39 | 1· |
| March ..... | 2·19 | ·86 | 2·41 | 1·12 | 2·62 | 1·16 | 3·08 | 1·40 | 2·28 | ·78 | 2·59 | 1· |
| April ..... | 1·69 | ·77 | 1·56 | ·70 | 1·40 | ·73 | 1·40 | 1·25 | ·55 | ·79 | 1·40 | 1· |
| May ..... | ·88 | 1·89 | ·70 | 2·11 | ·86 | 1·99 | 1·50 | 1·92 | 1·36 | 1·79 | 1·88 | 2· |
| June ..... | 1·54 | 1·28 | 2·06 | 1·53 | 2·12 | 1·58 | 1·35 | 2·05 | ·90 | 1·37 | 1·22 | 2· |
| July ..... | ·61 | 3·84 | ·94 | 3·03 | 1·00 | 4·23 | ·88 | 5·50 | ·56 | 3·60 | ·58 | 1· |
| August ..... | ·62 | 5·09 | ·88 | 8·46 | 1·12 | 8·51 | 1·24 | 4·00 | ·76 | 2·16 | 1·36 | 3· |
| September ... | 2·58 | ·05 | 3·56 | ·05 | 3·36 | ·02 | 3·68 | ·08 | 2·16 | ·09 | 1·50 | · |
| October ..... | 1·37 | 5·37 | 1·98 | 4·67 | 1·90 | 4·97 | 2·25 | 6·46 | 1·79 | 3·31 | 1·80 | 3· |
| November ... | 1·46 | 3·91 | 2·36 | 3·25 | 2·95 | 3·25 | 3·30 | 3·67 | 2·26 | 2·31 | 1·80 | 1· |
| December ... | 2·50 | 2·72 | 2·08 | 2·73 | 1·98 | 3·42 | 2·25 | 2·78 | 2·10 | 1·82 | 1·98 | 1· |
| Totals ..... | 17·96 | 29·96 | 21·93 | 33·82 | 22·75 | 36·50 | 24·68 | 35·82 | 17·11 | 21·82 | 17·23 | 23· |

## SCOTLAND.

### Division XIII.—South-Eastern Counties.

| .XII.—DUN. (*co*). | | Division XIII.—South-Eastern Counties. | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UNTRIES *ontinued*). | | Selkirk. | | Peebles. | | Berwick. | | Haddington. | | | | Edinburgh. | |
| ılockhead. | | Selkirk Bowhill. | | Penicuick N. Esk Reservoir. | | Thirlestane Castle. | | Yester. | | East Linton. | | Glencorse. | |
| ft. 4 in. 1330 ft. | | 4 ft. 0 in. 537 ft. | | 0 ft. 6 in. 1150 ft. | | 0 ft. 3 in. 558 ft. | | 1 ft. 0 in. 420 ft. | | 0 ft. 3 in. 90 ft. | | 0 ft. 6 in. 787 ft. | |
| 4. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| . | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| ·11 | 5·36 | 1·58 | 2·77 | 2·40 | 5·25 | 2·00 | 1·90 | 1·45 | 3·60 | ·91 | 2·15 | 2·20 | 3·65 |
| ·46 | 3·84 | 1·73 | 1·57 | 2·55 | 1·60 | 2·45 | 2·30 | 2·30 | 1·40 | 2·43 | ·56 | 3·10 | 1·75 |
| ·77 | 2·97 | 3·33 | 1·45 | 4·40 | 1·20 | 3·50 | 1·30 | 2·25 | 1·25 | 3·16 | ·81 | 4·05 | 1·55 |
| ·97 | ·72 | ·77 | ·63 | 1·05 | ·45 | ·80 | ·90 | ·85 | 1·25 | ·70 | ·78 | ·90 | ·40 |
| 1·12 | 6·45 | 2·35 | 3·17 | 1·90 | 4·30 | 2·60 | 3·20 | 2·15 | 5·15 | 1·90 | 5·27 | 1·90 | 6·05 |
| 4·69 | ·60 | 2·10 | 1·10 | 2·45 | ·70 | 1·10 | ·10 | ·95 | 1·85 | 1·43 | ·25 | 1·45 | ·40 |
| 5·79 | 2·00 | 1·30 | 2·13 | 2·30 | 4·25 | 1·70 | 2·10 | ·90 | 2·70 | 1·82 | 3·07 | 2·20 | 3·40 |
| 1·14 | 1·38 | ·88 | 3·13 | 1·05 | 4·65 | 1·00 | 3·90 | 1·60 | 3·10 | 1·18 | 2·28 | ·65 | 4·50 |
| 9·18 | 1·46 | 3·49 | ·45 | 3·98 | 1·00 | 3·85 | ·90 | 2·90 | 1·25 | 2·48 | ·65 | 3·60 | ·70 |
| 4·15 | 4·74 | 5·25 | 5·90 | 7·95 | 7·60 | 6·85 | 7·70 | 11·60 | 9·05 | 10·43 | 5·89 | 9·90 | 6·55 |
| 6·43 | 5·93 | 3·26 | 3·33 | 2·95 | 3·10 | 3·20 | 2·20 | 4·05 | 2·90 | 1·95 | 1·20 | 3·20 | 2·95 |
| 5·86 | 10·42 | 2·78 | 3·06 | 3·00 | 2·60 | 2·70 | 2·30 | 3·15 | 2·60 | 1·53 | ·96 | 2·65 | 2·70 |
| 8·67 | 52·87 | 28·82 | 28·69 | 35·98 | 36·70 | 31·75 | 28·80 | 34·15 | 36·10 | 29·92 | 23·87 | 35·80 | 34·60 |

### Division XIV.—South-Western Counties (*continued*).

| Lanark *continued*). | | Ayr. | | | | | | Renfrew. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| hotts, Hill nd House. | | Girvan. | | Ayr, Achendrane House. | | Mansfield, Largs. | | Nither Place, Mearns. | | Paisley Stanley Reservoir. | | Greenock. | |
| 7 ft. 0 in. 620 ft. | | 0 ft. 6 in. 15 ft. | | 2 ft. 3 in. 94 ft. | | 0 ft. 6 in. 30 ft. | | 0 ft. 5 in. 350 ft. | | ..... 100 ft. | | 0 ft. 6 in. 50 ft. | |
| 864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| 2·37 | 1·55 | 4·50 | 6·70 | 2·40 | 3·74 | 4·20 | 5·20 | 5·50 | 3·75 | 4·10 | 4·40 | 6·37 | 6·80 |
| 2·52 | ·53 | 2·50 | 3·50 | 2·65 | 2·73 | 4·20 | 3·00 | 4·38 | 2·75 | 3·60 | 3·38 | 5·77 | 4·40 |
| 3·80 | ·91 | 7·20 | 2·80 | 4·95 | 2·20 | 3·90 | 2·40 | 8·12 | 2·38 | 5·60 | 2·07 | 6·37 | 2·83 |
| 1·21 | ·64 | 2·60 | ·50 | 2·05 | ·67 | 3·30 | ·70 | 2·13 | 1·12 | 2·60 | ·57 | 3·00 | 1·30 |
| 1·40 | 3·04 | 1·40 | 4·20 | 2·03 | 4·06 | 2·20 | 2·70 | 1·00 | 3·00 | 1·20 | 3·60 | 1·93 | 3·88 |
| 2·62 | ·59 | 3·50 | 1·20 | 2·33 | 1·28 | 2·90 | 1·00 | 4·50 | 1·13 | 3·30 | ·65 | 4·23 | ·95 |
| 3·02 | 2·67 | 3·00 | 2·50 | 2·32 | 1·91 | 3·00 | 2·80 | 3·00 | 2·25 | 2·70 | 2·68 | 3·33 | 2·64 |
| 1·58 | 4·58 | 2·10 | 4·30 | 1·80 | 4·82 | 2·30 | 7·20 | 2·50 | 5·50 | 1·40 | 4·35 | 1·97 | 6·77 |
| 4·24 | 1·06 | 5·00 | 1·10 | 5·80 | 1·16 | 5·60 | 1·90 | 6·25 | 2·00 | 5·50 | 1·23 | 7·60 | 1·70 |
| 4·92 | 4·10 | 3·20 | 5·10 | 3·24 | 3·10 | 2·60 | 4·70 | 5·62 | 5·12 | 3·50 | 4·60 | 2·93 | 6·40 |
| 2·23 | 2·61 | 5·50 | 4·96 | 4·02 | 2·88 | 5·50 | 3·60 | 4·25 | 4·13 | 3·20 | 4·10 | 6·83 | 4·65 |
| 2·19 | 1·90 | 2·85 | 4·80 | 3·22 | 2·51 | 3·10 | 4·60 | 4·50 | 5·25 | 3·10 | 5·00 | 5·47 | 7·11 |
| 32·10 | 24·18 | 43·35 | 41·66 | 36·80 | 31·06 | 42·80 | 39·80 | 51·75 | 38·38 | 39·80 | 36·63 | 55·80 | 49·43 |

## ENGLAND AND WALES.

| Division VI.—West Midland Counties (*continued*). | | | | | Division VII.—North Midland Counties | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Warwick (*continued*). | | | | | Leicester. | | | | | | Lincoln | |
| Height of Rain-gauge above Ground ..... Sea-level..... | Edgbaston, Birmingham. 1 ft. 6 in. 510 ft. | | Birmingham. 0 ft. 10 in. 340 ft. | | Wigston. 0 ft. 6 in. 220 ft. | | Thornton Reservoir. 2 ft. 8 in. 420? ft. | | Belvoir Castle. 1 ft. 0 in. 237 ft. | | Great Hall 0 ft. 9 ..... | |
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1 |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | i |
| January ..... | 1·22 | 3·17 | 1·15 | 3·08 | ·88 | 2·33 | ·84 | 1·98 | ·57 | 2·59 | ·78 | |
| February ... | 2·02 | 2·60 | 1·77 | 2·63 | 1·71 | 2·43 | 2·12 | 1·80 | ·98 | 2·06 | 1·34 | |
| March ..... | 3·47 | 1·43 | 3·44 | 1·23 | 2·42 | 1·01 | 2·70 | ·89 | 2·75 | 1·31 | 2·84 | |
| April ..... | 1·41 | 1·33 | 1·45 | ·60 | 1·74 | ·40 | 1·30 | ·40 | 1·89 | ·67 | ·83 | |
| May ..... | 1·60 | 3·00 | 1·59 | 2·87 | 1·88 | 3·00 | 2·40 | 2·17 | ·96 | 2·34 | 1·59 | |
| June ..... | 1·61 | 2·34 | 1·63 | 2·36 | 1·36 | 2·29 | 2·12 | 2·42 | 1·33 | 1·41 | ·84 | |
| July ..... | ·83 | 3·85 | ·88 | 3·89 | ·30 | 3·25 | ·44 | 3·25 | ·25 | 3·00 | ·32 | |
| August ..... | ·66 | 4·47 | ·48 | 4·59 | ·54 | 3·54 | ·51 | 4·20 | ·56 | 3·54 | ·50 | |
| September ... | 3·13 | ·18 | 3·46 | ·21 | 1·50 | ·22 | 1·70 | ·26 | 1·69 | ·21 | 1·24 | |
| October ..... | 2·75 | 5·63 | 2·56 | 5·06 | 1·66 | 4·88 | 1·67 | 5·74 | 1·34 | 4·78 | 1·41 | |
| November ... | 2·67 | 2·31 | 2·42 | 2·25 | 2·19 | 2·42 | 2·48 | 1·97 | 1·99 | 2·38 | 2·05 | |
| December ... | 2·74 | 1·25 | 2·68 | 1·10 | 1·42 | 1·03 | 1·26 | ·74 | 2·03 | ·93 | 1·37 | |
| Totals ..... | 24·11 | 31·56 | 23·51 | 29·87 | 17·60 | 26·80 | 19·54 | 25·32 | 16·34 | 25·22 | 15·11 | |

| Division VII.—North Midland Counties (*continued*). | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nottinghamshire. | | | | | Derbyshire. | | | | | | | |
| Height of Rain-gauge above Ground ..... Sea-level..... | Welbeck. 3 ft. 10 in. ..... | | East Retford. 2 ft. 0 in. 50 ft. | | Derby. 5 ft. 0 in. 180 ft. | | Chesterfield. 3 ft. 6 in. 248 ft. | | Comb's Moss. 3 ft. 6 in. 1669 ft. | | Chapel-en-Frith 3 ft. 6 in. 965 ft. | |
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1 |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | |
| January ..... | 1·03 | 2·03 | ·86 | 1·96 | 1·08 | 2·00 | 1·02 | 1·85 | 2·23 | 3·00 | 1·85 | |
| February ... | 1·32 | 1·69 | 1·46 | 1·61 | 2·52 | 2·06 | 1·87 | 1·83 | 3·49 | 2·89 | 2·90 | |
| March ..... | 2·03 | ·69 | 2·09 | 1·44 | 2·49 | 1·04 | 2·67 | ·68 | 2·10 | 1·63 | 3·09 | |
| April ..... | 1·34 | ·95 | 1·18 | 1·07 | 2·10 | ·97 | 1·92 | 1·87 | 1·33 | 1·72 | 1·78 | |
| May ..... | 4·18 | 3·21 | 4·74 | 3·21 | 1·67 | 2·63 | 1·31 | 2·90 | 4·67 | 3·76 | 2·32 | |
| June ..... | 1·33 | 1·08 | 1·88 | 1·45 | 1·21 | 1·83 | ·81 | 1·13 | 4·25 | 1·18 | 3·54 | |
| July ..... | 1·17 | 2·86 | 1·07 | 2·86 | ·74 | 2·68 | ·31 | 2·77 | 2·37 | 3·57 | 1·91 | |
| August ..... | 1·89 | 3·74 | 1·76 | 2·47 | ·71 | 3·25 | 1·03 | 4·29 | 3·72 | 5·93 | 3·33 | |
| September ... | 1·93 | ·58 | 2·02 | ·16 | 3·23 | ·15 | 2·73 | ·05 | 3·70 | ·51 | 4·00 | |
| October ..... | 2·94 | 4·86 | 2·91 | 4·79 | 2·07 | 5·20 | 2·96 | 6·13 | 3·52 | 8·99 | 2·43 | |
| November ... | 2·21 | 2·21 | 2·16 | 2·09 | 1·99 | 1·90 | 3·18 | 2·71 | 7·10 | 6·67 | 4·78 | |
| December ... | 1·23 | ·61 | 1·97 | ·63 | 1·93 | ·75 | 1·53 | ·88 | 3·70 | 2·18 | 2·95 | |
| Totals ..... | 22·60 | 24·51 | 24·10 | 23·74 | 21·74 | 24·46 | 21·34 | 27·09 | 42·18 | 42·03 | 34·94 | |

# SCOTLAND.

## Division XV.—West Midland Counties (*continued*).

### Argyll (*continued*).

| Rhins of Islay. | | M'Arthur's Head. | | Tarbert, Stonefield. | | Castle Toward. | | Dunoon, Hafton. | | Otter House. | | Lochgilphead, Kilmory. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 ft. 0 in. 74 ft.? | | 0 ft. 4 in. 106 ft.? | | 1 ft. 3 in. 90 ft. | | 4 ft. 0 in. 80 ft. | | 4 ft. 0 in. 40 ft. | | 0 ft. 6 in. 130 ft. | | 0 ft. 4 in. 100 ft. | |
| 64. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| n. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| 1·64 | 3·83 | 5·10 | 7.30 | 5.60 | 8·70 | 4·09 | 5·30 | 7·15 | 8·00 | 4·34 | 6·49 | 5·20 | 7·00 |
| 1·86 | 4·32 | 4·00 | 5.20 | 4·30 | 4·50 | 3·56 | 4·29 | 6·02 | 5·40 | 5·54 | 4·54 | 3·10 | 8·10 |
| 1·82 | 2·35 | 6·40 | 5.00 | 6.20 | 4·45 | 5·10 | 2·76 | 8·19 | 3·66 | 6·47 | 2·62 | 5·20 | 3·50 |
| 1·35 | 1·27 | 5·00 | 2.00 | 3.00 | 1·55 | 2·23 | 1·23 | 3·00 | 1·68 | 3·39 | 1·59 | 3·00 | 1·70 |
| ·76 | 2·41 | 2·50 | 3.70 | 2.20 | 4·40 | 1·72 | 3·89 | 2·09 | 4·22 | 1·75 | 3·86 | 2·10 | 4·20 |
| 2·19 | ·70 | 2·80 | .70 | 3.70 | 1·58 | 3·01 | 1·43 | 5·14 | 1·84 | 3·99 | 1·54 | 3·80 | 1·50 |
| 2·47 | 2·26 | 3·20 | 3.50 | 4.00 | 3·76 | 3·22 | 3·56 | 4·86 | 3·35 | 4·71 | 3·74 | 5·20 | 4·10 |
| 2·34 | 4·65 | 5·30 | 6.50 | 3.70 | .7·45 | 2·76 | 7·20 | 3·28 | 8·00 | 4·73 | 5·96 | 3·60 | 6·00 |
| 4·23 | ·89 | 8·70 | 1.70 | 7.80 | 2·00 | 6·80 | 1·34 | 9·14 | 2·06 | 7·79 | 1·35 | 8·00 | 2·00 |
| 2·30 | 4·59 | 3·40 | 6.70 | 2.80 | 5·50 | 3·39 | 4·16 | 3·10 | 5·54 | 2·45 | 5·91 | 3·60 | 4·50 |
| 3·13 | 4·99 | 8·00 | 6.30 | 7.60 | 6·10 | 6·61 | 4·01 | 8·81 | 4·82 | 7·30 | 4·31 | 6·50 | 5·90 |
| 2·02 | 2·09 | 6·00 | 5.80 | 5.30 | 5·80 | 4·36 | 4·72 | 7·73 | 7·85 | 3·68 | 5·93 | 4·20 | 6·70 |
| 37·17 | 34·35 | 60·40 | 54.40 | 56.20 | 55·79 | 46·85 | 43·89 | 68.51 | 56·42 | 56·14 | 47·84 | 53·50 | 55·20 |

| Div. XV. (*cont.*). | | Division XVI.—East Midland Counties. | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Argyll (*continued*). | | Clackmannan. | | Kinross. | | Fife. | | Perth. | | | | | |
| Ardnamurchan. | | Dollar. | | Loch Leven Sluice. | | Leven Nookton. | | Dunblane, Kippenross. | | Deanston. | | Loch Katrine. | |
| 3 ft. 6 in. 82 ft.? | | 0 ft. 4 in. 170 ft. | | 0 ft. 10 in. ..... | | 0 ft. 6 in. 80 ft. | | 0 ft. 4 in. 100 ft. | | 0 ft. 2 in. 130 ft. | | 0 ft. 6 in. 830 ft. | |
| 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| 3·18 | 4·76 | 3·89 | 3·57 | 3·10 | 2·80 | 1·91 | 1·33 | 5·30 | 2·90 | 4·45 | 2·76 | 8·00 | 7·20 |
| 2·76 | 2·98 | 1·99 | 2·79 | 3·50 | 2·70 | 3·25 | 1·83 | 3·05 | 2·50 | 4·55 | 2·95 | 6·50 | 5·40 |
| 3·97 | 3·03 | 3·61 | 2·06 | 4·00 | 1·00 | 2·95 | ·99 | 4·80 | 1·70 | 5·05 | 1·91 | 4·80 | 3·30 |
| 3·77 | 1·80 | 1·16 | ·80 | 1·00 | ·70 | 1·15 | ·62 | 1·05 | ·55 | 1·55 | ·99 | 3·60 | 1·90 |
| 2·16 | 3·13 | 1·99 | 2·77 | 1·30 | 2·80 | 1·23 | 2·99 | 1·35 | 2·30 | 1·58 | 2·98 | 1·75 | 4·90 |
| 3·91 | 1·46 | 2·42 | ·54 | 2·00 | ·40 | 2·35 | ·38 | 2·75 | ·05 | 3·84 | ·46 | 6·75 | 1·10 |
| 2·38 | 3·73 | 1·57 | 5·05 | 2·40 | 3·80 | 1·74 | 4·04 | 3·10 | 3·20 | 3·85 | 3·20 | 3·80 | 5·00 |
| 3·60 | 4·24 | ·82 | 5·67 | ·90 | 5·00 | 1·35 | 2·38 | 1·50 | 5·40 | 1·62 | 5·21 | 4·70 | 7·30 |
| 8·44 | 2·32 | 5·74 | 1·15 | 3·70 | ·40 | 3·09 | ·64 | 4·05 | ·80 | 4·46 | 1·15 | 9·30 | 2·80 |
| 3·11 | 3·13 | 5·56 | 4·96 | 6·60 | 7·60 | 5·44 | 5·12 | 5·25 | 5·10 | 4·43 | 4·23 | 5·00 | 6·80 |
| 4·65 | 5·56 | 2·43 | 2·90 | 3·40 | 3·60 | 2·27 | 3·23 | 3·55 | 3·65 | 3·30 | 3·31 | 8·70 | 6·40 |
| 4·24 | 4·64 | 5·44 | 3·94 | 4·20 | 3·30 | 3·02 | 2·22 | 2·45 | 4·20 | 3·22 | 4·60 | 8·40 | 9·60 |
| 46·17 | 40·78 | 36·62 | 36.20 | 36·10 | 34.10 | 29·75 | 25·77 | 38·20 | 32·35 | 41·90 | 33·75 | 71·20 | 61·70 |

## SCOTLAND.

### Division XVI.—East Midland Counties (*continued*).

| Height of Rain-gauge above Ground ..... Sea-level..... | Perth (*continued*). Auchterarder House. 2 ft. 3 in. 162 ft. | | Stronvar, Loch Earn Head. 0 ft. 5 in. 463 ft. | | Trinity Gask. 0 ft. 1 in. 133 ft. | | Scone Palace. 2 ft. 6 in. 80 ft.? | | Stanley. 1 ft. 0 in. 200 ft. | | Forfar. Dundee, Somerville Place. 0 ft. 3 in. 240 ft. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| January ..... | 3·15 | 1·25 | 8·50 | 8·30 | 4·05 | 2·10 | 2·52 | 1·67 | 3·27 | 1·92 | 2·28 | 2·5 |
| February ... | 2·79 | 1·45 | 5·80 | 4·55 | 3·10 | 2·25 | 2·94 | 1·66 | 2·85 | 1·95 | 2·60 | 2·7 |
| March ..... | 2·00 | 1·50 | 6·52 | 2·93 | 3·60 | 1·10 | 2·56 | 1·08 | 2·10 | ·99 | 2·80 | 1·6 |
| April ..... | 1·39 | ·80 | 3·45 | 1·60 | 1·20 | ·75 | ·91 | ·53 | ·77 | ·42 | 1·07 | ·9 |
| May ..... | 1·39 | 1·49 | 1·85 | 5·58 | 1·20 | 2·25 | 1·59 | 2·14 | 1·71 | 2·31 | 2·07 | 2·3 |
| June ..... ... | 2·39 | 1·25 | 5·67 | ·85 | 2·10 | ·40 | 1·61 | ·35 | 2·10 | ·32 | 2·20 | ·6 |
| July ..... | 2·80 | 3·00 | 5·45 | 4·10 | 2·80 | 3·60 | 2·35 | 5·19 | 2·31 | 4·95 | 2·80 | 4·3 |
| August ..... | 1·15 | 5·20 | 2·45 | 6·30 | 1·50 | 4·35 | ·74 | 3·94 | ·56 | 3·67 | ·95 | 3·1 |
| September ... | 3·60 | 3·66 | 10·25 | 2·10 | 4·75 | ·50 | 2·96 | ·65 | 3·71 | ·58 | 3·80 | ·7 |
| October ..... | 4·70 | 5·70 | 5·25 | 5·55 | 5·20 | 5·40 | 4·01 | 5·82 | 3·23 | 4·60 | 5·90 | 6·5 |
| November ... | 3·50 | 3·4 | 8·73 | 6·30 | 3·60 | 3·60 | 3·18 | 2·70 | 3·05 | 2·60 | 3·40 | 3·2 |
| December ... | 4·65 | 4·00 | 7·75 | 13·95 | 4·10 | 4·25 | 3·33 | 3·06 | 2·94 | 3·15 | 4·10 | 2·3 |
| Totals ..... | 33·51 | 32·70 | 71·67 | 62·11 | 37·20 | 30·55 | 28·70 | 28·79 | 28·60 | 27·46 | 33·97 | 30·59 |

### Div. XVII.—North Eastern Counties (*continued*). Div. XVIII.—N.-Western Counties

| Height of Rain-gauge above Ground ..... Sea-level..... | Aberdeen (*continued*). Castle Newe. 1 ft. 0 in. 915 ft. | | Ellon, Tillydesk. 0 ft. 4 in. 349 ft. | | Moray. Elgin Institution. 0 ft. 6 in. 33 ft. | | West Ross. Loch Alsh, Inverinate House. 3 ft. 0 in. 150 ft. | | East Ross. Cromarty. 3 ft. 4 in. 28 ft. | | Ardross Castle Alness. 1 ft. 0 in. 450 ft. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| January ..... | ·82 | 4·10 | 1·32 | 2·08 | ·93 | 3·40 | 6·20 | 5·27 | ·38 | 2·61 | ·90 | 4·4 |
| February ... | 2·35 | 3·91 | 3·38 | 3·40 | 1·80 | 2·27 | 5·70 | 1·85 | 3·20 | 1·25 | 5·06 | 1·9 |
| March ..... | 3·35 | 2·90 | 2·20 | 3·12 | 2·35 | 1·51 | 4·70 | ·93 | 2·04 | 1·02 | 4·12 | 2·9 |
| April ..... | 1·24 | ·51 | 1·04 | ·60 | 1·35 | ·77 | 3·45 | 2·35 | ·97 | ·56 | 1·25 | 1·1 |
| May ..... | 2·31 | 2·43 | 2·63 | 1·32 | 2·60 | 1·62 | 3·25 | 3·62 | 1·58 | 1·73 | 1·97 | 2·0 |
| June ..... | 1·71 | ·41 | 1·61 | 1·04 | 1·46 | ·42 | 5·60 | 2·59 | 1·70 | ·15 | 1·98 | ·4 |
| July ..... | 2·10 | 3·86 | 2·56 | 3·78 | 4·13 | 2·71 | 4·50 | 7·25 | 1·08 | 3·15 | 1·67 | 1·6 |
| August ..... | 1·47 | 3·25 | 1·70 | 2·53 | 1·24 | 3·15 | 4·30 | 6·76 | 1·33 | 1·83 | 1·71 | 1·7 |
| September ... | 4·36 | ·34 | 2·91 | ·66 | 3·86 | ·80 | 8·20 | 6·53 | 2·87 | ·80 | 2·20 | 1·0 |
| October ..... | 8·30 | 5·72 | 4·35 | 4·64 | 4·88 | 2·82 | 3·80 | 6·62 | 4·42 | 2·99 | 7·76 | 7·1 |
| November ... | 5·70 | 2·68 | 5·93 | 2·60 | 2·70 | 2·48 | 4·85 | 4·47 | 1·82 | 2·08 | 3·20 | 2·9 |
| December .. | 2·77 | 3·24 | 3·33 | 1·32 | 2·22 | 1·16 | 7·75 | 8·49 | 1·93 | 1·34 | 3·52 | 2·2 |
| Totals ..... | 36·48 | 33·35 | 32·96 | 27·09 | 29·52 | 23·11 | 62·30 | 56·73 | 23·32 | 19·51 | 35·34 | 29·6 |

## ENGLAND AND WALES.

### Division IX.—Yorkshire.

| ...nball Park, ...effield. | | Redmires, Sheffield. | | Tickhill. | | West Melton. | | Penistone. | | Saddleworth. | | Longwood, Huddersfield. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ...t 0 in. ...37 ft. | | 4 ft. 0 in. 1100 ft. | | 2 ft. 0 in. 61 ft. | | 0 ft. 10 in. 172 ft. | | 3 ft. 6 in. 717 ft. | | 5 ft. 0 in. 640 ft. | | 4 ft. 6 in. 609 ft. | |
| ...t. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| 9 | 2·35 | 1·61 | 3·20 | ·80 | 1·28 | ·70 | ·49 | ·80 | 1·59 | 1·47 | 3·93 | 1·47 | 2·30 |
| 12 | 2·13 | 2·83 | 2·10 | 1·29 | 1·53 | 1·79 | ·96 | 2·00 | 1·66 | 3·57 | 3·51 | 2·18 | 1·59 |
| 10 | ·87 | 3·67 | 1·36 | 2·48 | ·81 | 2·68 | ·50 | 1·57 | ·72 | 3·27 | 1·37 | 2·55 | ·77 |
| 22 | 1·41 | 2·26 | 2·88 | 1·51 | 1·11 | 1·52 | 1·67 | ·94 | 1·70 | 1·26 | 1·73 | 1·15 | 1·14 |
| 38 | 3·55 | 2·33 | 2·80 | 1·64 | 2·82 | 1·64 | 2·42 | 3·08 | 3·27 | 3·79 | 2·48 | 2·25 | 2·40 |
| 32 | 1·55 | 2·50 | 1·26 | 1·38 | 1·54 | ·98 | 1·25 | ·95 | 1·00 | 3·52 | 1·42 | 1·92 | 1·03 |
| 34 | 1·91 | ·98 | 1·77 | ·63 | 4·31 | ·64 | 2·38 | ·43 | 1·74 | 1·89 | 2·40 | ·96 | 2·72 |
| 134 | 5·42 | 2·23 | 4·99 | 1·62 | 3·45 | 1·66 | 3·07 | 1·40 | 3·98 | 1·70 | 5·72 | 1·28 | 3·64 |
| 107 | 13 | 2·80 | ·39 | 1·51 | ·12 | 1·35 | ·94 | 2·81 | ·12 | 4·21 | ·77 | 2·67 | ·29 |
| 373 | 583 | 4·22 | 7·15 | 2·35 | 5·02 | 2·80 | 3·41 | 5·93 | 6·76 | 4·30 | 5·42 | 3·31 | 5·69 |
| 216 | 276 | 4·31 | 3·52 | 2·35 | 2·56 | 2·03 | 2·33 | 2·91 | 3·40 | 4·32 | 3·10 | 3·14 | 2·94 |
| 79 | ·78 | 2·14 | 1·10 | 1·80 | ·71 | 1·29 | ·62 | 1·98 | ·79 | 1·45 | 1·20 | 1·51 | 1·57 |
| 36 | 28·69 | 31·88 | 32·47 | 19·36 | 25·26 | 19·08 | 20·04 | 24·80 | 26·73 | 34·75 | 33·05 | 24·39 | 26·08 |

### Division IX.—Yorkshire (*continued*).

| Yorkshire—West Riding (*continued*). | | | | | | | | Yorkshire—East Riding. | | | | Yorkshire—N. Riding. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| York. | | Harrogate. | | Settle. | | Arncliffe. | | Beverly Road, Hull. | | Holme, on Spalding Moor. | | Malton. | |
| ...ft. 6 in. ...50 ft. | | 0 ft. 6 in. 420 ft. | | 40 ft. 0 in. 498 ft. | | 3 ft. 0 in. 750 ft. | | 3 ft. 10 in. 11 ft. | | 3 ft. 0 in. 30 ft. | | 1 ft. 0 in. 73 ft. | |
| 64. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| 82 | 1·07 | 1·23 | 2·62 | 3·17 | 3·03 | 4·18 | 6·00 | ·99 | 1·51 | ·94 | 1·72 | 1·07 | 1·20 |
| 15 | 1·55 | 1·93 | 2·04 | 3·12 | 3·28 | 3·89 | 3·64 | 1·91 | 1·48 | 1·43 | 1·79 | 1·74 | 1·53 |
| 78 | 1·18 | 2·91 | 1·63 | 2·98 | 1·66 | 3·90 | 2·90 | 1·68 | 1·58 | 1·81 | 1·30 | 1·88 | 1·86 |
| 76 | 1·51 | 1·75 | 1·25 | 1·54 | 1·80 | 2·24 | 1·50 | 1·05 | ·77 | 1·16 | 1·49 | 1·31 | 1·50 |
| 78 | 1·91 | 2·63 | 2·22 | 1·57 | 3·71 | 1·78 | 5·72 | 1·32 | 2·54 | 3·03 | 2·56 | 2·62 | 2·72 |
| 36 | 1·09 | 2·36 | ·90 | 2·84 | ·79 | 4·64 | ·60 | 1·19 | 1·03 | 1·59 | 1·10 | 2·37 | ·44 |
| 47 | 1·82 | ·70 | 1·91 | 1·30 | 2·82 | 1·92 | 2·79 | ·46 | 1·84 | ·80 | 2·53 | ·93 | 1·42 |
| 16 | 5·28 | ·89 | 4·44 | 2·16 | 5·84 | 2·61 | 6·87 | 1·11 | 4·96 | 1·85 | 4·45 | ·79 | 3·42 |
| 31 | ·23 | 2·10 | ·30 | 3·99 | ·77 | 6·70 | 1·63 | 2·02 | ·47 | 2·09 | ·29 | 2·13 | ·17 |
| 57 | 4·43 | 4·75 | 5·79 | 2·86 | 6·34 | 3·19 | 6·92 | 2·08 | 4·36 | 1·55 | 4·97 | 3·16 | 4·43 |
| 45 | 2·06 | 2·35 | 3·43 | 4·38 | 3·81 | 5·63 | 6·60 | 2·12 | 2·28 | 2·83 | 2·10 | 2·44 | 3·35 |
| 52 | 1·06 | 2·88 | 1·17 | 2·69 | 1·53 | 5·10 | 2·09 | 2·34 | ·98 | 2·26 | ·86 | 2·41 | 1·28 |
| 15 | 21·19 | 26·48 | 27·70 | 32·60 | 35·38 | 45·78 | 47·26 | 18·27 | 23·80 | 21·14 | 25·16 | 22·85 | 23·32 |

## SCOTLAND.

### Division XIX.—Northern Counties.

| Height of Rain-gauge above | Sutherland. Dunrobin Castle. Ground 0 ft. 6 in. Sea-level 6 ft. | | Sutherland. House of Tongue. Ground 0 ft. 1 in. Sea-level 33 ft. | | Sutherland. Cape Wrath. Ground 3 ft. 6 in. Sea-level 355 ft.? | | Caithness. Noss-head. Ground 3 ft. 4 in. Sea-level 127 ft. | | Caithness. Holburnhead, Thurso. Ground 0 ft. 4 in. Sea-level 60 ft.? | | Caithness. Pentland Skerries. Ground 3 ft. 3 in. Sea-level 72 ft. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| January | ·75 | 4·30 | 1·70 | 5·70 | 2·00 | 5·02 | ·60 | 2·14 | ·60 | 2·22 | ·97 | 2·[illegible] |
| February | 4·60 | 2·23 | 12·70 | 1·90 | 4·15 | 2·29 | 2·92 | 1·44 | 4·05 | 2·37 | 5·91 | 1·[illegible] |
| March | 3·35 | 2·65 | 4·30 | 6·20 | 2·90 | 2·75 | 3·45 | 2·72 | ·67 | 2·57 | 2·85 | 3·[illegible] |
| April | ·70 | ·52 | ·50 | 1·20 | 1·66 | 1·71 | ·40 | ·68 | ·52 | 1·03 | 1·00 | 1·[illegible] |
| May | 2·00 | ·90 | 2·00 | ·70 | 1·49 | 1·39 | ·97 | ·29 | 1·15 | ·87 | 1·60 | 1·[illegible] |
| June | 1·10 | ·38 | 2·20 | ·30 | 3·61 | 1·64 | 1·60 | ·15 | 1·01 | 1·23 | 1·65 | 1·[illegible] |
| July | 1·45 | 1·84 | 2·20 | 2·00 | 2·70 | 1·80 | 1·57 | 1·92 | ·61 | 1·90 | 1·99 | 3·[illegible] |
| August | 1·08 | 1·76 | 1·20 | 1·70 | 3·52 | 3·84 | 2·26 | ·55 | ·90 | 1·91 | 2·04 | 1·[illegible] |
| September | 4·20 | ·81 | 3·90 | 1·10 | 4·97 | 3·05 | 2·60 | ·55 | 1·36 | 2·21 | 2·46 | 1·[illegible] |
| October | 3·83 | 3·60 | 4·60 | 3·50 | 3·06 | 4·38 | 4·88 | 2·05 | 1·90 | 3·95 | 5·60 | 3·[illegible] |
| November | 2·80 | 1·00 | 4·80 | 2·40 | 3·66 | 2·72 | 4·61 | 2·18 | 2·10 | 3·12 | 4·88 | 2·[illegible] |
| December | 2·30 | 1·07 | 3·60 | 2·20 | 4·47 | 2·21 | 1·37 | ·42 | 3·27 | 1·53 | 2·99 | 1·[illegible] |
| Totals | 28·16 | 21·06 | 43·70 | 28·90 | 38·19 | 32·80 | 27·23 | 15·09 | 18·14 | 24·91 | 31·94 | 26·[illegible] |

### Division XX.—Munster (*continued*). Div. XXI.—Leinste[illegible]

| Height of Rain-gauge above | Waterford. Waterford. Ground 4 ft. 0 in. Sea-level 60 ft. | | Waterford. Portlaw. Ground 20 ft. 0 in. Sea-level 50 ft. | | Clare. Killaloe. Ground 5 ft. 0 in. Sea-level 128 ft. | | Clare. Ennis. Ground 2 ft. 6 in. Sea-level 35 ft. | | Kilkenny. Kilkenny. Ground 0 ft. 6 in. Sea-level 200 ft. | | Queen's C[illegible] Portarlington. Ground 1 ft. 1 in. Sea-level 236 ft. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| January | 3·75 | 4·29 | 6·06 | 4·03 | 2·95 | 6·13 | 2·49 | 5·25 | 3·79 | 3·28 | 3·97 | 4·5[illegible] |
| February | 1·77 | 3·17 | 2·38 | 3·08 | 1·88 | 5·16 | 1·96 | 2·90 | ·83 | 4·18 | 1·15 | 5·4[illegible] |
| March | 3·18 | 1·70 | 3·66 | 2·19 | 2·85 | 3·42 | 2·17 | 2·45 | 2·42 | 2·13 | 3·74 | 5·4[illegible] |
| April | 1·85 | 1·10 | 1·45 | 1·85 | 1·22 | ·45 | 1·28 | 0·75 | 1·95 | ·94 | 2·08 | 1·0[illegible] |
| May | 1·67 | 4·54 | 1·94 | 5·12 | 1·84 | 5·52 | 1·43 | 3·57 | 2·11 | 3·51 | 3·18 | 4·8[illegible] |
| June | 1·20 | ·68 | 2·16 | ·59 | 3·39 | 2·19 | 2·44 | 1·10 | 2·32 | ·87 | 2·12 | 1·0[illegible] |
| July | 1·73 | 3·62 | 1·28 | 4·40 | 1·64 | 3·54 | ·53 | 1·54 | ·75 | 2·68 | ·79 | 5·4[illegible] |
| August | 1·53 | 5·08 | 1·12 | 4·71 | 1·63 | 4·34 | 2·04 | ·51 | 3·31 | 3·32 | 2·50 | 5·0[illegible] |
| September | 3·23 | ·55 | 3·77 | ·51 | 5·63 | 1·10 | 6·02 | 1·50 | 3·73 | ·88 | 6·23 | ·5[illegible] |
| October | 5·05 | 4·07 | 5·54 | 4·29 | 3·23 | 5·05 | ·10 | 3·62 | 4·46 | 3·29 | 5·87 | 5·8[illegible] |
| November | 4·91 | 6·00 | 6·36 | 8·75 | 6·48 | 5·06 | 5·25 | 5·20 | 5·62 | 2·89 | 6·31 | 3·8[illegible] |
| December | 4·59 | 6·22 | 4·55 | 7·73 | 2·90 | 4·08 | 2·73 | 3·72 | 3·89 | 2·46 | 4·51 | 2·7[illegible] |
| Totals | 34·46 | 41·02 | 40·27 | 47·25 | 35·64 | 46·04 | 28·44 | 32·11 | 35·18 | 30·43 | 42·45 | 43·8[illegible] |

SCOTLAND. IRELAND.

| Division XIX.—Northern Counties (*continued*). | | | | | | | | | | Div. XX.—Munster. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Orkney. | | | | Shetland. | | | | | | Cork. | | Kerry. | |
| our Castle. | | Sandwick Lawn. | | Sumburghead. | | Bressay Manse. | | East Yell. | | Cork, Queen's College. | | Valentia. | |
| ft. 3 in. 50 ft. | | 2 ft. 0 in. 78 ft. | | 3 ft. 4 in. 265 ft. ? | | 0 ft. 9 in. 12 ft. | | 3 ft. 0 in. 176 ft. | | 6 ft. 0 in. 65 ft. | | 2 ft. 0 in. 30 ft. | |
| 54. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| . | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| ·10 | 2·55 | 1·37 | 4·08 | 1·54 | 2·67 | 2·70 | 4·80 | 2·88 | 6·00 | 4·07 | 4·22 | 5·44 | 8·02 |
| ·20 | 1·90 | 3·78 | 3·40 | 1·81 | 1·96 | 4·00 | 4·20 | 3·10 | 1·90 | 1·67 | 3·00 | 2·89 | 3·71 |
| ·10 | 2·20 | 2·69 | 4·74 | ·99 | 2·44 | 3·20 | 2·60 | 7·76 | 4·88 | 3·24 | 3·82 | 3·96 | 4·19 |
| ·10 | 1·10 | 1·23 | 1·47 | 1·38 | ·91 | 1·70 | 2·00 | 1·85 | 1·47 | 1·77 | 1·54 | 1·55 | 1·71 |
| ·50 | 1·25 | 1·88 | 1·90 | 1·05 | 1·01 | 2·80 | 1·60 | 1·74 | 1·68 | 2·44 | 4·36 | 2·51 | 3·54 |
| ·30 | 1·07 | 1·90 | 1·42 | 1·62 | ·58 | 2·00 | ·50 | 3·19 | 1·04 | 2·06 | ·66 | 4·92 | 1·31 |
| ·00 | 2·10 | 1·63 | 1·55 | 1·93 | 1·24 | 3·40 | 2·40 | 2·80 | 1·86 | ·70 | 3·35 | 1·44 | 2·35 |
| ·90 | 3·20 | 2·60 | 2·66 | 2·39 | 1·91 | 3·50 | 2·20 | 3·60 | 3·34 | 1·87 | 4·39 | 3·44 | 6·17 |
| ·80 | 1·60 | 3·69 | 2·28 | 1·97 | 1·75 | 3·20 | 1·90 | 2·35 | 1·98 | 2·77 | ·85 | 5·32 | 4·11 |
| ·10 | 4·28 | 3·66 | 4·85 | 2·27 | 1·01 | 4·50 | 2·20 | 5·09 | 4·82 | 4·81 | 3·29 | 2·72 | 8·60 |
| ·70 | 2·30 | 4·69 | 3·07 | 3·37 | 2·72 | 6·50 | 4·10 | 4·35 | 6·94 | 5·78 | 6·84 | 8·04 | 9·08 |
| ·55 | 1·90 | 4·16 | 2·79 | 3·58 | 2·27 | 5·50 | 3·60 | 3·60 | 2·18 | 3·43 | 6·69 | 5·39 | 6·30 |
| 975 | 25·45 | 33·28 | 34·21 | 23·90 | 20·47 | 43·00 | 32·10 | 42·31 | 38·09 | 34·61 | 43·01 | 47·62 | 59·09 |

| Division XXI.—Leinster (*continued*). | | | | | | | | | | | | Div. XXII. Connaught. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kings Co. | | | | Wicklow. | | Dublin. | | | | | | Galway. | |
| Birr Castle, Parsonstown. | | Tullamore. | | Bray, Fassaroe. | | Black Rock. | | Dublin. | | Glasnevin. | | Gort, Cregg Park. | |
| 0 ft. 3 in. 200 ft. | | 3 ft. 0 in. 235 ft. | | 5 ft. 0 in. 250 ft. | | 29 ft. 0 in. 95 ft. | | 18 ft. 0 in. 42 ft. | | 6 ft. 6 in. 66 ft. | | 3 ft. 0 in. 120 ft. | |
| 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| 1·81 | 3·88 | 1·78 | 2·05 | 3·09 | 4·03 | 1·83 | 3·18 | 2·45 | 2·29 | 1·45 | 1·49 | 2·23 | 4·23 |
| ·68 | 2·71 | ·71 | 2·48 | 1·22 | 4·29 | ·89 | 2·19 | 1·17 | 2·68 | 1·03 | 1·79 | 1·98 | 3·38 |
| 2·64 | 1·80 | 2·41 | 1·98 | 4·12 | 1·83 | 3·03 | 1·21 | 3·51 | 1·94 | 2·58 | 1·15 | 3·10 | 2·58 |
| 1·17 | 1·05 | 1·13 | ·72 | ·46 | 1·85 | ·58 | 1·61 | 1·20 | 1·50 | ·73 | 1·10 | 1·35 | 1·32 |
| 1·65 | 3·69 | 1·15 | 3·36 | 1·38 | 4·82 | 1·78 | 2·89 | 1·70 | 3·92 | 1·59 | 3·12 | 2·07 | 3·44 |
| 3·25 | ·85 | 2·53 | ·87 | 1·63 | ·79 | 1·26 | ·47 | 1·35 | ·70 | 1·14 | ·75 | 2·45 | 1·75 |
| ·81 | 3·19 | ·56 | 2·18 | ·41 | 4·42 | ·59 | 2·71 | 1·06 | 3·62 | ·87 | 2·03 | 1·17 | 5·66 |
| 1·73 | 2·82 | 1·56 | 2·99 | 1·38 | 4·46 | 1·47 | 4·32 | 1·35 | 2·84 | ·92 | 3·95 | 2·02 | 4·15 |
| 3·34 | ·48 | 3·27 | ·29 | 2·01 | ·09 | 1·65 | ·02 | 2·46 | ·11 | 1·59 | ·03 | 5·50 | ·97 |
| 3·75 | 4·03 | 3·94 | 3·66 | 7·24 | 5·38 | 6·44 | 4·13 | 5·65 | 3·74 | 6·13 | 3·35 | 3·29 | 2·89 |
| 4·07 | 4·21 | 3·26 | 3·87 | 5·62 | 6·00 | 4·01 | 3·78 | 4·67 | 3·09 | 3·85 | 2·71 | 6·55 | 3·71 |
| 2·14 | 3·19 | 1·68 | 2·47 | 3·10 | 4·25 | 2·20 | 3·29 | 3·18 | 2·80 | 2·07 | 2·87 | 2·18 | 4·35 |
| 2·04 | 31·90 | 23·98 | 26·92 | 31·66 | 42·21 | 25·73 | 29·80 | 29·75 | 29·23 | 23·95 | 24·34 | 33·89 | 38·43 |

## ENGLAND AND WALES.

### Division XI.—Monmouth, Wales, and the Islands.

| Height of Rain-gauge above Ground ..... Sea-level..... | Monmouth. Abercarn. 1 ft. 3 in. 450 ft. | | Blaina, Tredegar. 0 ft. 9 in. 1100 ft. | | Abergavenny. 1 ft. 3 in. ..... | | Glamorgan. Swansea. 16 ft. 0 in. 30 ft. | | Ystalyfera. 1 ft. 0 in. 368 ft. | | Carmarthe Carmarthen 0 ft. 5 in. 78 ft. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 186 |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| January ..... | 4·53 | 5·80 | 4·59 | 4·75 | 2·42 | 3·35 | 2·22 | 3·47 | 4·34 | 7·04 | 3·72 | 7·1 |
| February ... | 2·58 | 2·21 | 2·46 | 4·46 | 1·67 | 3·13 | 1·78 | 2·52 | 3·13 | 4·89 | 1·96 | 4·6 |
| March ..... | 4·27 | 1·76 | 3·83 | 1·76 | 3·28 | 1·51 | 2·05 | 1·74 | 3·53 | 2·96 | 3·14 | 2·7 |
| April ..... | ·50 | ·63 | 1·53 | ·67 | 1·20 | ·69 | ·76 | 2·49 | 1·34 | 1·74 | 1·12 | 1·5 |
| May ..... | 1·36 | 4·28 | ·94 | 4·08 | ·94 | 3·19 | 1·20 | 2·59 | 1·68 | 7·15 | 1·82 | 5·7 |
| June ..... | 3·11 | 1·31 | 2·89 | 2·32 | 1·40 | 1·53 | 1·74 | 2·06 | 4·06 | 2·56 | 3·79 | 1·2 |
| July ..... | 1·28 | 3·03 | 1·38 | 3·34 | ·49 | 2·53 | ·77 | 3·10 | 2·27 | 5·88 | 2·09 | 3·1 |
| August ..... | 2·05 | 4·82 | 2·19 | 6·17 | 1·41 | 3·79 | 1·69 | 3·61 | 3·95 | 7·22 | 3·18 | 6·6 |
| September ... | 6·04 | ·22 | 6·28 | ·22 | 2·95 | ·01 | 4·70 | ·11 | 7·83 | 1·12 | 6·94 | ·5 |
| October ..... | 3·76 | 10·51 | 3·83 | 7·89 | 2·78 | 6·90 | 1·85 | 5·47 | 2·51 | 7·60 | 2·57 | 7·3 |
| November ... | 7·64 | 5·79 | 7·25 | 6·13 | 6·44 | 5·47 | 3·50 | 3·74 | 6·60 | 7·98 | 4·89 | 6·1 |
| December ... | 3·33 | 5·39 | 2·95 | 4·28 | 2·20 | 3·66 | 2·48 | 2·15 | 3·70 | 5·55 | 3·67 | 5·4 |
| Totals ..... | 40·45 | 45·75 | 40·12 | 46·07 | 27·18 | 35·76 | 24·74 | 33·05 | 44·94 | 61·69 | 38·89 | 50·4 |

### Division XI.—Monmouth, Wales, and the Islands (*continued*).

| Height of Rain-gauge above Ground ..... Sea-level..... | Flint. Hawarden. 1 ft. 0 in. 260 ft. | | Maes-y-dre. 5 ft. 0 in. 400 ft. | | Denbigh. Llandudno. 0 ft. 6 in. 99 ft. | | Merioneth. Talgarth Hall. 1 ft. 0 in. 150? ft. | | Brithdin, Dolgelly. 1 ft. 0 in. 500 ft. | | Carnarvon. Bangor. 5 ft. 0 in. 105 ft. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1 |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| January ..... | 1·11 | 1·95 | ·22 | 2·35 | 2·19 | 2·43 | 4·13 | 5·35 | 4·72 | 6·98 | 2·78 | 3·1 |
| February ... | 1·35 | 1·75 | ·25 | ·68 | ·92 | 1·51 | 2·90 | 4·77 | 3·98 | 4·18 | 1·99 | 2·1 |
| March ..... | 3·32 | 1·54 | 2·35 | 1·36 | 3·01 | 1·34 | 3·45 | 4·37 | 3·70 | 3·66 | 3·24 | 2·1 |
| April ..... | 1·62 | ·73 | 1·58 | ·80 | 1·71 | ·74 | 3·37 | 1·36 | 1·31 | 3·06 | ·97 | ·9 |
| May ..... | 2·32 | 2·83 | 1·90 | 2·70 | 2·67 | 3·18 | 3·93 | 5·30 | 1·36 | 4·91 | 2·19 | 4·1 |
| June ..... | 1·65 | 1·22 | 2·03 | 1·11 | 1·81 | 1·81 | 9·79 | 2·98 | 3·62 | 1·90 | 5·04 | 1·7 |
| July ..... | ·67 | 1·19 | 1·01 | 2·13 | ·99 | 1·46 | 2·95 | 3·70 | 1·50 | 4·30 | 2·40 | 3·1 |
| August ..... | 1·32 | 4·37 | 1·67 | 3·16 | 2·49 | 5·68 | 3·87 | 5·92 | 2·71 | 4·98 | 2·58 | 4·1 |
| September ... | 2·13 | ·11 | 3·03 | ·23 | 2·09 | ·13 | 7·24 | 1·50 | 5·82 | ·75 | 4·65 | ·7 |
| October ..... | 2·69 | 3·07 | 3·03 | 3·43 | 2·51 | 4·95 | 2·64 | 1·62 | 3·25 | 7·08 | 3·22 | 3·1 |
| November ... | 2·10 | 2·36 | 2·40 | 2·16 | 3·61 | 3·20 | 5·39 | 5·25 | 6·53 | 7·49 | 4·86 | 4·2 |
| December ... | 1·39 | ·84 | 1·72 | 1·11 | 1·35 | 1·68 | 3·35 | 1·20 | 2·73 | 8·30 | 2·77 | 2·1 |
| Totals ..... | 21·67 | 21·96 | 21·19 | 21·22 | 25·35 | 28·11 | 53·01 | 43·32 | 41·23 | 57·59 | 36·69 | 33·1 |

## ENGLAND AND WALES.

### Division XI.—Monmouth, Wales, and the Islands (*continued*).

| ARMARTHEN (*continued*). | | Pembroke. | | | | Cardigan. | | | | Brecknock. | | Radnor. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rhydwen. | | Pembroke Dock. | | Haverford-west. | | Lampeter. | | Frongoch. | | Pen-y-Maes. | | Cefnfaes, Rhayader. | |
| 1 ft. 0 in. 150 ft. | | 4 ft. 0 in. 30 ft. | | 2 ft. 0 in. 60 ft. | | 5 ft. 0 in. 420 ft. | | 4 ft 0. in. 855 ft. | | 1 ft. 0 in. 400 ft. | | 2 ft. 0 in. 880 ft. | |
| 864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| n. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| 5·00 | 4·71 | 5·60 | 4·54 | 5·12 | 4·50 | 3·59 | 4·57 | 4·82 | 4·58 | 1·41 | 1·83 | 2·70 | 6·00 |
| 2·28 | 3·52 | 2·12 | 4·74 | 1·88 | 4·37 | 1·49 | 3·52 | ·75 | 4·13 | 1·01 | 3·30 | 3·32 | 2·50 |
| 2·80 | 3·29 | 3·31 | 2·68 | 2·15 | 3·14 | 2·08 | 2·40 | 2·67 | 2·59 | 1·60 | 1·40 | 3·67 | 1·47 |
| 1·24 | 1·60 | 1·02 | 1·93 | 1·15 | 2·28 | 1·18 | ·26 | 3·14 | 1·34 | ·95 | ·88 | 1·50 | 1·00 |
| 1·28 | 4·32 | 1·36 | 3·84 | 1·40 | 5·75 | 2·17 | 5·44 | 2·58 | 3·68 | 1·57 | 3·89 | 1·50 | 5·29 |
| 1·52 | 1·18 | 2·95 | 1·01 | 2·71 | 1·33 | 2·92 | 1·42 | 2·84 | 1·75 | 1·40 | 1·45 | 2·38 | 1·40 |
| 2·54 | 3·89 | 1·54 | 3·04 | 2·90 | 3·80 | 1·13 | 3·20 | 2·43 | 3·82 | ·67 | 2·09 | 1·20 | 4·00 |
| 1·64 | 5·57 | 1·50 | 5·31 | 2·05 | 5·15 | ·81 | 6·32 | 3·85 | 5·56 | ·59 | 4·00 | 1·70 | 4·64 |
| 5·62 | ·47 | 4·40 | ·31 | 5·53 | ·43 | 6·48 | ·31 | 4·46 | 1·42 | 5·14 | ·00 | 6·10 | ·25 |
| 3·85 | 5·84 | 3·50 | 6·50 | 3·40 | 7·91 | 3·71 | 5·27 | 3·31 | 5·97 | 3·92 | 5·29 | 3·75 | 7·00 |
| 6·25 | 5·86 | 4·21 | 5·40 | 5·65 | 7·64 | 4·33 | 6·08 | 4·50 | 4·14 | 2·82 | 4·46 | 6·90 | 4·84 |
| 3·61 | 3·08 | 5·40 | 3·34 | 6·12 | 4·47 | 2·69 | 3·60 | 1·85 | 4·76 | 2·20 | 2·40 | 2·30 | 3·09 |
| 3·98 | 43·33 | 36·91 | 42·64 | 40·06 | 50·77 | 32·58 | 42·39 | 37·20 | 43·74 | 23·28 | 30·99 | 37·02 | 41·48 |

### Division XI.—Monmouth, Wales, and the Islands (*continued*).

| Carnarvon (*continued*), | | Isle of Man. | | | | | | Channel Islands. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Llanfairfe-chan. | | Calf of Man. | | Douglas. | | Point of Ayr. | | Guernsey. | | Millbrook, Jersey. | | Gorey, Jersey. | |
| 0 ft. 8 in. 150 ft. | | 0 ft. 10 in. 325 ? ft. | | 0 ft. 6 in. ..... | | 3 ft. 4 in. 27 ft. ? | | 12 ft. 0 in. 204 ft. | | 0 ft. 6 in. 50 ft. | | 0 ft. 6 in. 90 ft. | |
| 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| 1·19 | 3·72 | 2·22 | 2·02 | 4·40 | 4·40 | 2·14 | 2·78 | 2·51 | 7·77 | 1·77 | 7·00 | 1·54 | 5·78 |
| 1·50 | 2·61 | 1·22 | 2·11 | 1·40 | 4·10 | 1·31 | 2·55 | 2·06 | 4·21 | 2·30 | 3·31 | 2·49 | 3·39 |
| 3·67 | 1·34 | 4·44 | 1·01 | 5·80 | 2·80 | 5·44 | 1·45 | 4·69 | 2·86 | 3·56 | 3·35 | 3·08 | 2·23 |
| 1·30 | ·84 | 2·21 | ·53 | 2·70 | ·70 | 1·50 | ·24 | ·96 | 2·04 | ·73 | 2·05 | ·54 | 2·00 |
| 2·17 | 5·25 | 1·08 | 2·91 | 1·20 | 3·80 | 1·63 | 3·39 | ·82 | 2·69 | 1·37 | 2·88 | ·99 | ·30 |
| 2·39 | 1·93 | 1·86 | ·85 | 1·90 | ·80 | 1·26 | ·63 | 2·49 | ·44 | ·98 | 1·51 | 1·49 | ·97 |
| 1·88 | 2·55 | ·75 | 1·54 | ·90 | 1·20 | 1·32 | 1·01 | 1·08 | 2·16 | 1·65 | 2·19 | ·82 | ·16 |
| 1·89 | 4·04 | ·81 | 2·18 | 2·60 | 2·70 | 1·36 | 3·88 | 2·57 | 3·46 | 2·63 | 1·95 | 2·55 | 1·52 |
| 3·43 | ·37 | 2·46 | ·36 | 4·40 | ·70 | 4·01 | ·53 | 4·33 | ·25 | 3·54 | ·93 | 3·22 | ·82 |
| 4·28 | 4·10 | 2·99 | 2·85 | 3·50 | 4·30 | 2·87 | 4·09 | 1·50 | 9·05 | ·95 | 7·47 | 1·16 | 6·52 |
| 5·78 | 4·29 | 2·89 | 3·17 | 4·90 | 4·60 | 2·99 | 3·84 | 7·00 | 6·49 | 4·52 | 3·48 | 3·64 | 2·80 |
| 1·91 | 2·66 | 2·14 | 2·76 | 3·90 | 3·70 | 2·29 | 2·76 | 2·65 | 1·93 | 1·95 | 2·92 | 1·33 | 2·88 |
| 31·39 | 33·80 | 25·07 | 22·29 | 37·60 | 33·80 | 28·12 | 27·15 | 32·66 | 43·35 | 25·95 | 39·04 | 22·85 | 29·37 |

ENGLAND & WALES. SCOTLAND.

| Div. XI.—(*continued*). | Division XII.—Southern Counties. | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Channel Islands (*continued*). | Wigton. | | Kirkcudbright. | | | | | | | | Dumfries. | |
| Height of Rain-gauge above Ground ..... Sea-level..... | Alderney. 10 ft. 0 in. 48 ft. | | Stranraer, S. Cairn. 0 ft. 4 in. 209 ft. | | Little Ross. 3 ft. 3 in. 130 ft. | | Castle Douglas, Slogarie. 0 ft. 6 in. 800 ft. | | Cargen. 0 ft. 3 in. 80 ft. | | Drumlanrig. 0 ft. 4 in. 191 ft. | |
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| January ..... | 1·27 | 3·59 | 4·70 | 4·30 | 1·50 | 1·94 | 8·51 | 7·00 | 3·78 | 4·12 | 4·60 | 4·0 |
| February ... | 1·66 | 2·22 | 3·35 | 4·15 | 1·26 | 3·05 | 3·48 | 4·50 | 2·77 | 2·96 | 3·00 | 2·7 |
| March ..... | 2·82 | 1·68 | 5·65 | 3·20 | 3·92 | ·86 | 6·51 | 2·79 | 3·88 | 1·49 | 4·00 | 2·0 |
| April ..... | ·58 | 1·76 | 3·20 | ·80 | 1·96 | ·44 | 2·78 | ·80 | 1·40 | ·71 | 2·10 | ·7 |
| May ..... | 1·02 | 1·86 | 1·65 | 4·55 | 1·25 | 2·94 | 2·29 | 7·14 | 1·42 | 6·66 | 1·30 | 6·1 |
| June ..... | ·76 | 2·68 | 3·30 | 1·20 | 1·14 | ·61 | 4·79 | ·80 | 3·41 | ·52 | 3·20 | ·0 |
| July ..... | ·43 | 1·52 | 3·15 | 3·65 | ·78 | 1·59 | 2·94 | 4·75 | 2·29 | 2·75 | 2·30 | 2·7 |
| August ..... | 1·62 | 1·95 | 2·60 | 3·60 | 1·27 | 1·84 | 3·17 | 5·84 | 1·44 | 4·98 | 1·10 | 5·9 |
| September ... | 6·81 | ·02 | 5·40 | ·65 | 3·77 | ·73 | 8·50 | 2·20 | 6·21 | 1·18 | 7·00 | ·9 |
| October ..... | ·86 | 7·34 | 2·75 | 5·40 | 3·34 | 5·49 | 5·17 | 6·45 | 4·92 | 5·96 | 4·20 | 3·9 |
| November ... | 4·12 | 3·69 | 4·20 | 6·20 | 3·12 | 3·02 | 7·87 | 7·32 | 4·70 | 4·78 | 4·60 | 3·8 |
| December ... | 2·61 | 2·26 | 2·50 | 3·60 | 3·28 | 2·73 | 9·94 | 8·19 | 3·90 | 5·08 | 4·60 | 6·8 |
| Totals ..... | 20·56 | 30·57 | 42·45 | 41·30 | 26·59 | 25·24 | 65·95 | 57·78 | 40·12 | 41·19 | 42·00 | 39·5 |

| Div. XIII.—Southern Counties *cont.* | Div. XIV.—South-Western Counties. | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Edinburgh (*continued*). | Lanark. | | | | | | | | | | | |
| Height of Rain-gauge above Ground ..... Sea-level..... | Invereak. 2 ft. 0 in. 60 ft. | | Edinburgh, Charlotte-sq. 0 ft. 6 in. 230 ft. | | Douglas Castle Newmains. 0 ft. 2 in. 783 ft. | | Auchinraith. 4 ft. 2 in. 150 ft. | | Glasgow Observatory. 0 ft. 3 in. 200 ft. | | Baillieston. 0 ft. 3 in. 230 ft. | |
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| January ..... | 1·19 | 3·20 | 1·25 | 2·29 | 5·80 | 6·75 | 2·05 | 1·62 | 3·65 | 4·26 | 3·32 | 3·65 |
| February ... | 2·36 | 1·09 | 2·14 | 1·70 | 4·42 | 3·82 | 2·15 | 1·55 | 3·93 | 1·79 | 3·92 | 2·95 |
| March ..... | 2·66 | 1·06 | 3·10 | ·99 | 6·75 | 2·06 | 3·65 | 1·40 | 4·09 | 2·06 | 4·91 | 1·61 |
| April ..... | 1·21 | ·58 | 1·16 | ·30 | 2·05 | ·56 | 1·45 | ·35 | 2·23 | ·85 | 1·99 | 1·13 |
| May ..... | 2·31 | 4·55 | 2·13 | 3·65 | 1·69 | 5·37 | 1·35 | 3·60 | 1·51 | 3·51 | 1·72 | 5·05 |
| June ..... | 2·17 | ·32 | 1·20 | ·41 | 3·95 | ·37 | 1·85 | ·45 | 3·37 | ·64 | 2·99 | ·85 |
| July ..... | 1·61 | 3·25 | 2·15 | 3·20 | 2·97 | 3·30 | 2·70 | 2·36 | 3·25 | 2·40 | 4·07 | 3·50 |
| August ..... | ·95 | 4·55 | ·80 | 3·41 | 1·20 | 4·30 | ·95 | 4·30 | 1·89 | 5·93 | 1·33 | 7·02 |
| September ... | 3·44 | ·60 | 3·40 | ·55 | 2·42 | ·44 | 3·85 | ·63 | 4·20 | 1·27 | 5·63 | 1·23 |
| October ..... | 8·06 | 4·99 | 6·90 | 3·96 | 4·83 | 2·58 | 3·55 | 3·38 | 3·17 | 4·69 | 5·72 | 4·18 |
| November ... | 2·27 | 2·26 | 1·79 | 1·60 | 5·02 | 3·13 | 2·20 | 2·34 | 3·19 | 3·43 | 3·31 | 3·38 |
| [illegible]ber ... | 1·79 | 1·33 | 2·07 | 1·59 | 3·78 | 3·74 | 1·60 | 2·30 | 2·67 | 4·54 | 2·80 | 3·52 |
| .... | 30·02 | 27·78 | 28·09 | 23·65 | 44·88 | 36·42 | 27·35 | 24·28 | 37·15 | 35·37 | 41·71 | 38·04 |

## SCOTLAND.

### Division XIII.—South-Eastern Counties.

| ·. XII.—OUN. (*co*). | | Division XIII.—South-Eastern Counties. | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UMBRIES (*continued*). | | Selkirk. | | Peebles. | | Berwick. | | Haddington. | | | | Edinburgh. | |
| nlockhead. | | Selkirk Bowhill. | | Penicuick N. Esk Reservoir. | | Thirlestane Castle. | | Yester. | | East Linton. | | Glencorse. | |
| ft. 4 in. 1330 ft. | | 4 ft. 0 in. 537 ft. | | 0 ft. 6 in. 1150 ft. | | 0 ft. 3 in. 558 ft. | | 1 ft. 0 in. 420 ft. | | 0 ft. 3 in. 90 ft. | | 0 ft. 6 in. 787 ft. | |
| 64. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| ı | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| ·11 | 5·36 | 1·58 | 2·77 | 2·40 | 5·25 | 2·00 | 1·90 | 1·45 | 3·60 | ·91 | 2·15 | 2·20 | 3·65 |
| ·46 | 3·84 | 1·73 | 1·57 | 2·55 | 1·60 | 2·45 | 2·30 | 2·30 | 1·40 | 2·43 | ·56 | 3·10 | 1·75 |
| ·77 | 2·97 | 3·33 | 1·45 | 4·40 | 1·20 | 3·50 | 1·30 | 2·25 | 1·25 | 3·16 | ·81 | 4·05 | 1·55 |
| ·97 | ·72 | ·77 | ·63 | 1·05 | ·45 | ·80 | ·90 | ·85 | 1·25 | ·70 | ·78 | ·90 | ·40 |
| ·12 | 6·45 | 2·35 | 3·17 | 1·90 | 4·30 | 2·60 | 3·20 | 2·15 | 5·15 | 1·90 | 5·27 | 1·90 | 6·05 |
| ·69 | ·60 | 2·10 | 1·10 | 2·45 | ·70 | 1·10 | ·10 | ·95 | 1·85 | 1·43 | ·25 | 1·45 | ·40 |
| ·79 | 2·00 | 1·30 | 2·13 | 2·30 | 4·25 | 1·70 | 2·10 | ·90 | 2·70 | 1·82 | 3·07 | 2·20 | 3·40 |
| ·14 | 1·38 | ·88 | 3·13 | 1·05 | 4·65 | 1·00 | 3·90 | 1·60 | 3·10 | 1·18 | 2·28 | ·65 | 4·50 |
| ·18 | 1·46 | 3·49 | ·45 | 3·98 | 1·00 | 3·85 | ·90 | 2·90 | 1·25 | 2·48 | ·65 | 3·60 | ·70 |
| ·15 | 4·74 | 5·25 | 5·90 | 7·95 | 7·60 | 6·85 | 7·70 | 11·60 | 9·05 | 10·43 | 5·89 | 9·90 | 6·55 |
| ·43 | 5·93 | 3·26 | 3·33 | 2·95 | 3·10 | 3·20 | 2·20 | 4·05 | 2·90 | 1·95 | 1·20 | 3·20 | 2·95 |
| ·86 | 10·42 | 2·78 | 3·06 | 3·00 | 2·60 | 2·70 | 2·30 | 3·15 | 2·60 | 1·53 | ·96 | 2·65 | 2·70 |
| ·67 | 52·87 | 28·82 | 28·69 | 35·98 | 36·70 | 31·75 | 28·80 | 34·15 | 36·10 | 29·92 | 23·87 | 35·80 | 34·60 |

### Division XIV.—South-Western Counties (*continued*).

| Lanark (*continued*). | | Ayr. | | | | | | Renfrew. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Shotts, Hill End House. | | Girvan. | | Ayr, Achendrane House. | | Mansfield, Largs. | | Nither Place, Mearns. | | Paisley Stanley Reservoir. | | Greenock. | |
| 7 ft. 0 in. 620 ft. | | 0 ft. 6 in. 15 ft. | | 2 ft. 3 in. 94 ft. | | 0 ft. 6 in. 30 ft. | | 0 ft. 5 in. 350 ft. | | ..... 100 ft. | | 0 ft. 6 in. 50 ft. | |
| 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| 2·37 | 1·55 | 4·50 | 6·70 | 2·40 | 3·74 | 4·20 | 5·20 | 5·50 | 3·75 | 4·10 | 4·40 | 6·37 | 6·80 |
| 2·52 | ·53 | 2·50 | 3·50 | 2·65 | 2·73 | 4·20 | 3·00 | 4·38 | 2·75 | 3·60 | 3·38 | 5·77 | 4·40 |
| 3·80 | ·91 | 7·20 | 2·80 | 4·95 | 2·20 | 3·90 | 2·40 | 8·12 | 2·38 | 5·60 | 2·07 | 6·37 | 2·83 |
| 1·21 | ·64 | 2·60 | ·50 | 2·05 | ·67 | 3·30 | ·70 | 2·13 | 1·12 | 2·60 | ·57 | 3·00 | 1·30 |
| 1·40 | 3·04 | 1·40 | 4·20 | 2·03 | 4·06 | 2·20 | 2·70 | 1·00 | 3·00 | 1·20 | 3·60 | 1·93 | 3·88 |
| 2·62 | ·59 | 3·50 | 1·20 | 2·33 | 1·28 | 2·90 | 1·00 | 4·50 | 1·13 | 3·30 | ·65 | 4·23 | ·95 |
| 3·02 | 2·67 | 3·00 | 2·50 | 2·32 | 1·91 | 3·00 | 2·80 | 3·00 | 2·25 | 2·70 | 2·68 | 3·33 | 2·64 |
| 1·58 | 4·58 | 2·10 | 4·30 | 1·80 | 4·82 | 2·30 | 7·20 | 2·50 | 5·50 | 1·40 | 4·35 | 1·97 | 6·77 |
| 4·24 | 1·06 | 5·00 | 1·10 | 5·80 | 1·16 | 5·60 | 1·90 | 6·25 | 2·00 | 5·50 | 1·23 | 7·60 | 1·70 |
| 4·92 | 4·10 | 3·20 | 5·10 | 3·24 | 3·10 | 2·60 | 4·70 | 5·62 | 5·12 | 3·50 | 4·60 | 2·93 | 6·40 |
| 2·23 | 2·61 | 5·50 | 4·96 | 4·02 | 2·88 | 5·50 | 3·60 | 4·25 | 4·13 | 3·20 | 4·10 | 6·83 | 4·65 |
| 2·19 | 1·90 | 2·85 | 4·80 | 3·22 | 2·51 | 3·10 | 4·60 | 4·50 | 5·25 | 3·10 | 5·00 | 5·47 | 7·11 |
| 32·10 | 24·18 | 43·35 | 41·66 | 36·80 | 31·06 | 42·80 | 39·80 | 51·75 | 38·38 | 39·80 | 36·63 | 55·80 | 49·43 |

## SCOTLAND.

### Division XV.—West Midland.

| Height of Rain-gauge above Ground ..... Sea-level..... | Dumbarton. Balloch Castle. 0 ft. 4 in. 91 ft. | | Arddarock, Loch Long. 1 ft. 0 in. 80 ft. | | Stirling. Stirling, Polmaise. 0 ft. 1 in. 12 ft. | | Ben Lomond. 0 ft. 6 in. 1800 ft. | | Bute. Pladda. 3 ft. 3 in. 55 ft.? | | Arg. Dewar Campbel 3 ft. 4 75 ft. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| January ..... | 5·26 | 4·68 | 7·05 | 5·82 | 4·50 | 2·80 | 19·80 | 5·40 | 2·01 | 3·55 | 3·74 |
| February ... | 5·14 | 4·41 | 6·95 | 6·84 | 3·80 | 4·80 | | 3·80 | 1·80 | 2·81 | 3·69 |
| March ..... | 6·36 | 2·50 | 7·90 | 3·91 | 3·80 | 1·70 | | 1·90 | 3·60 | 2·14 | 5·45 |
| April ..... | 3·64 | ·96 | 3·55 | 1·74 | 1·80 | ·60 | 2·70 | ·90 | 1·92 | ·48 | 2·80 |
| May ..... | 1·63 | 3·14 | 1·89 | 4·35 | 1·50 | 2·20 | 1·40 | 8·10 | ·85 | 2·29 | 1·87 |
| June ..... | 4·29 | 1·16 | 5·47 | 1·35 | 3·20 | ·20 | 9·90 | ·60 | 1·92 | 1.14 | 2·65 |
| July ..... | 3·16 | 3·26 | 4·81 | 4·50 | 3·00 | 3·00 | 2·00 | 7·80 | 1·26 | 1·76 | 1·18 |
| August ..... | 2·42 | 7·04 | 2·98 | 6·86 | 1·50 | 4·20 | 6·00 | 12·10 | 1·39 | 2·17 | 2·83 |
| September ... | 6·36 | 1·94 | 11·22 | 2·63 | 4·30 | ·70 | 11·00 | 2·90 | 3·20 | 1·22 | 4·46 |
| October ..... | 3·57 | 5·92 | 4·31 | 9·12 | 3·00 | 4·70 | 4·40 | 5·80 | 1·74 | 4·13 | 1·60 |
| November ... | 4·83 | 4·57 | 8·59 | 5·61 | 3·00 | 3·00 | 8·90 | 6·10 | 2·01 | 3·87 | 4·61 |
| December ... | 3·21 | 5·62 | 5·88 | 8·06 | 2·60 | 4·70 | 8·00 | 11·80 | 1·83 | 1·39 | 3·64 |
| Totals ..... | 49·87 | 45·20 | 70·60 | 60·79 | 36·00 | 32·60 | 74·10 | 67·20 | 23·53 | 26·95 | 38·53 |

### Division XV.—West Midland Counties (*continued*).

Argyll (*continued*).

| Height of Rain-gauge above Ground ..... Sea-level..... | Fladda. 0 ft. 6 in. 20 ft.? | | Inverary Castle. 0 ft. 0 in. 30 ft. | | Oban. 0 ft. 4 in. 10 ft. | | Lismore. 3 ft. 4 in. 37 ft. | | Hynish. ..... ..... | | Loch Cor 0 ft. 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| January ..... | 4·80 | 5·80 | 6·00 | 1·50 | 5·80 | 8·20 | 3·88 | 4·91 | 7·88 | 9·67 | 6·30 |
| February ... | 3·90 | 4·50 | 4·00 | 2·00 | 3·70 | 4·10 | 3·12 | 2·90 | 6·42 | 10·66 | 6·30 |
| March ..... | 5·80 | 5·30 | 3·00 | 3·00 | 5·25 | 3·00 | 3·89 | 3·18 | 9·84 | 6·17 | 5·55 |
| April ..... | 5·00 | 3·80 | 4·00 | 2·50 | 3·70 | 2·60 | 3·06 | 2·02 | 5·15 | 3·32 | 5·55 |
| May ..... | 2·30 | 4·60 | 1·50 | 3·00 | 2·35 | 3·95 | 2·98 | 3·10 | 2·48 | 5·90 | 3·70 |
| June ..... | 5·50 | 3·20 | 3·00 | 1·50 | 4·70 | 2·35 | 4·33 | 1·70 | 4·81 | 2·39 | 10·40 |
| July ..... | 3·10 | 5·10 | 4·00 | 3·00 | 3·95 | 3·55 | 3·83 | 3·52 | 2·48 | 4·52 | 6·85 |
| August ..... | 6·20 | 8·90 | 3·50 | 6·00 | 3·80 | 6·35 | 3·15 | 4·32 | 3·92 | 6·80 | 5·05 |
| September ... | 8·60 | 2·60 | 4·50 | 2·00 | 11·08 | 3·70 | 10·21 | 1·84 | 13·99 | 3·54 | 15·30 |
| October ..... | 2·70 | 7·40 | 4·00 | 5·00 | 3·35 | 3·75 | 3·63 | 3·10 | 4·49 | 5·43 | 5·55 |
| November ... | 8·10 | 8·20 | 6·00 | 3·00 | 6·75 | 5·60 | 4·71 | 4·11 | 6·16 | 9·10 | 5·25 |
| December ... | 6·30 | 8·80 | 4·00 | 7·60 | 8·00 | 7·10 | 5·33 | 5·41 | 10·80 | 9·20 | 9·80 |
| Totals ..... | 62·30 | 68·20 | 47·50 | 40·10 | 62·43 | 54·25 | 52·12 | 40.11 | 78·42 | 76·70 | 85·55 |

## SCOTLAND.

### Division XV.—West Midland Counties (*continued*).

Argyll (*continued*).

| thins of Lisy. | | M'Arthur's Head. | | Tarbert, Stonefield. | | Castle Toward. | | Dunoon, Hafton. | | Otter House. | | Lochgilphead, Kilmory. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ft. 0 in. 74 ft.? | | 0 ft. 4 in. 106 ft.? | | 1 ft. 3 in. 90 ft. | | 4 ft. 0 in. 80 ft. | | 4 ft. 0 in. 40 ft. | | 0 ft. 6 in. 130 ft. | | 0 ft. 4 in. 100 ft. | |
| 4. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| 64 | 3·83 | 5·10 | 7·30 | 5.60 | 8·70 | 4·09 | 5·30 | 7·15 | 8·00 | 4·34 | 6·49 | 5·20 | 7·00 |
| 86 | 4·32 | 4·00 | 5.20 | 4·30 | 4·50 | 3·56 | 4·29 | 6·02 | 5·40 | 5·54 | 4·54 | 3·10 | 8·10 |
| 82 | 2·35 | 6·40 | 5.00 | 6.20 | 4·45 | 5·10 | 2·76 | 8·19 | 3·66 | 6·47 | 2·62 | 5·20 | 3·50 |
| 35 | 1·27 | 5·00 | 2.00 | 3.00 | 1·55 | 2·23 | 1·23 | 3·00 | 1·68 | 3·39 | 1·59 | 3·00 | 1·70 |
| 76 | 2·41 | 2·50 | 3.70 | 2.20 | 4·40 | 1·72 | 3·89 | 2·09 | 4·22 | 1·75 | 3·86 | 2·10 | 4·20 |
| 19 | ·70 | 2·80 | .70 | 3.70 | 1·58 | 3·01 | 1·43 | 5·14 | 1·84 | 3·99 | 1·54 | 3·80 | 1·50 |
| 4· | 2·26 | 3·20 | 3.50 | 4.00 | 3·76 | 3·22 | 3·56 | 4·86 | 3·35 | 4·71 | 3·74 | 5·20 | 4·10 |
| 34 | 4·65 | 5·30 | 6.50 | 3.70 | 7·45 | 2·76 | 7·20 | 3·28 | 8·00 | 4·73 | 5·96 | 3·60 | 6·00 |
| 23 | ·89 | 8·70 | 1.70 | 7.80 | 2·00 | 6·80 | 1·34 | 9·14 | 2·06 | 7·79 | 1·35 | 8·00 | 2·00 |
| 56 | 4·59 | 3·40 | 6.70 | 2.80 | 5·50 | 3·39 | 4·16 | 3·10 | 5·54 | 2·45 | 5·91 | 3·60 | 4·50 |
| 15 | 4·99 | 8·00 | 6.30 | 7.60 | 6·10 | 6·61 | 4·01 | 8·81 | 4·82 | 7·30 | 4·31 | 6·50 | 5·90 |
| 02 | 2·09 | 6·00 | 5.80 | 5.30 | 5·80 | 4·36 | 4·72 | 7·73 | 7·85 | 3·68 | 5·93 | 4·20 | 6·70 |
| 17 | 34·35 | 60·40 | 54.40 | 56.20 | 55·79 | 46·85 | 43·89 | 68.51 | 56·42 | 56·14 | 47·84 | 53·50 | 55·20 |

### Division XVI.—East Midland Counties.

| iv. XV. cont.). | | Argyll ntinued). | Clackmannan. | | Kinross. | | Fife. | | Perth. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| rdnamur-chan. | | | Dollar. | | Loch Leven Sluice. | | Leven Nookton. | | Dunblane, Kippenross. | | Deanston. | | Loch Katrine. | |
| 3 ft. 6 in. 82 ft.? | | | 0 ft. 4 in. 170 ft. | | 0 ft. 10 in. ..... | | 0 ft. 6 in. 80 ft. | | 0 ft. 4 in. 100 ft. | | 0 ft. 2 in. 130 ft. | | 0 ft. 6 in. 830 ft. | |
| 864. | 1865. | | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| 1. | in. | | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| 3·18 | 4·76 | | 3·89 | 3·57 | 3·10 | 2·80 | 1·91 | 1·33 | 5·30 | 2·90 | 4·45 | 2·76 | 8·00 | 7·20 |
| 1·76 | 2·98 | | 1·99 | 2·79 | 3·50 | 2·70 | 3·25 | 1·83 | 3·05 | 2·50 | 4·55 | 2·95 | 6·50 | 5·40 |
| 1·97 | 3·03 | | 3·61 | 2·06 | 4·00 | 1·00 | 2·95 | ·99 | 4·80 | 1·70 | 5·05 | 1·91 | 4·80 | 3·30 |
| 3·77 | 1·80 | | 1·16 | ·80 | 1·00 | ·70 | 1·15 | ·62 | 1·05 | ·55 | 1·55 | ·99 | 3·60 | 1·90 |
| 2·16 | 3·13 | | 1·99 | 2·77 | 1·30 | 2·80 | 1·23 | 2·99 | 1·35 | 2·30 | 1·58 | 2·98 | 1·75 | 4·90 |
| 3·91 | 1·46 | | 2·42 | ·54 | 2·00 | ·40 | 2·35 | ·38 | 2·75 | ·05 | 3·84 | ·46 | 6·75 | 1·10 |
| 2·38 | 3·73 | | 1·57 | 5·05 | 2·40 | 3·80 | 1·74 | 4·04 | 3·10 | 3·20 | 3·85 | 3·20 | 3·80 | 5·00 |
| 3·60 | 4·24 | | ·82 | 5·67 | ·90 | 5·00 | 1·35 | 2·38 | 1·50 | 5·40 | 1·62 | 5·21 | 4·70 | 7·30 |
| 8·44 | 2·32 | | 5·74 | 1·15 | 3·70 | ·40 | 3·09 | ·64 | 4·05 | ·80 | 4·46 | 1·15 | 9·20 | 2·80 |
| 3·11 | 3·13 | | 5·56 | 4·96 | 6·60 | 7·60 | 5·44 | 5·12 | 5·25 | 5·10 | 4·43 | 4·23 | 5·00 | 6·80 |
| 4·65 | 5·56 | | 2·43 | 2·90 | 3·40 | 3·60 | 2·27 | 3·23 | 3·55 | 3·65 | 3·30 | 3·31 | 8·70 | 6·40 |
| 4·24 | 4·64 | | 5·44 | 3·94 | 4·20 | 3·30 | 3·02 | 2·22 | 2·45 | 4·20 | 3·22 | 4·60 | 8·40 | 9·60 |
| 6·17 | 40·78 | | 36·62 | 36.20 | 36·10 | 34.10 | 29·75 | 25·77 | 38·20 | 32·35 | 41·90 | 33·75 | 71·20 | |

## SCOTLAND.

### Division XVI.—East Midland Counties (*continued*).

| | Perth (*continued*). | | | | | | | | | | Forfar. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Height of Rain-gauge above | Auchterarder House. | | Stronvar, Loch Earn Head. | | Trinity Gask. | | Scone Palace. | | Stanley. | | Dundee, Somerville Place. | |
| Ground ..... | 2 ft. 3 in. | | 0 ft. 5 in. | | 0 ft. 1 in. | | 2 ft. 6 in. | | 1 ft. 0 in. | | 0 ft. 3 in. | |
| Sea-level..... | 162 ft. | | 463 ft. | | 133 ft. | | 80 ft.? | | 200 ft. | | 240 ft. | |
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| January ..... | 3·15 | 1·25 | 8·50 | 8·30 | 4·05 | 2·10 | 2·52 | 1·67 | 3·27 | 1·92 | 2·28 | 2·50 |
| February ... | 2·79 | 1·45 | 5·80 | 4·55 | 3·10 | 2·25 | 2·94 | 1·66 | 2·85 | 1·95 | 2·60 | 2·70 |
| March ..... | 2·00 | 1·50 | 6·52 | 2·93 | 3·60 | 1·10 | 2·56 | 1·08 | 2·10 | ·99 | 2·80 | 1·60 |
| April ..... | 1·39 | ·80 | 3·45 | 1·60 | 1·20 | ·75 | ·91 | ·53 | ·77 | ·42 | 1·07 | ·86 |
| May ..... | 1·39 | 1·49 | 1·85 | 5·58 | 1·20 | 2·25 | 1·59 | 2·14 | 1·71 | 2·31 | 2·07 | 2·30 |
| June ..... ... | 2·39 | 1·25 | 5·67 | ·85 | 2·10 | ·40 | 1·61 | ·35 | 2·10 | ·32 | 2·20 | ·60 |
| July ..... | 2·80 | 3·00 | 5·45 | 4·10 | 2·80 | 3·60 | 2·35 | 5·19 | 2·31 | 4·95 | 2·80 | 4·35 |
| August ..... | 1·15 | 5·20 | 2·45 | 6·30 | 1·50 | 4·35 | ·74 | 3·94 | ·56 | 3·67 | ·95 | 3·15 |
| September ... | 3·60 | 3·66 | 10·25 | 2·10 | 4·75 | ·50 | 2·96 | ·65 | 3·71 | ·58 | 3·80 | ·70 |
| October ..... | 4·70 | 5·70 | 5·25 | 5·55 | 5·20 | 5·40 | 4·01 | 5·82 | 3·23 | 4·60 | 5·90 | 6·30 |
| November ... | 3·50 | 3·4 | 8·73 | 6·30 | 3·60 | 3·60 | 3·18 | 2·70 | 3·05 | 2·60 | 3·40 | 3·20 |
| December ... | 4·65 | 4·00 | 7·75 | 13·95 | 4·10 | 4·25 | 3·33 | 3·06 | 2·94 | 3·15 | 4·10 | 2·33 |
| Totals ..... | 33·51 | 32·70 | 71·67 | 62·11 | 37·20 | 30·55 | 28·70 | 28·79 | 28·60 | 27·46 | 33·97 | 30·59 |

### Div. XVII.—North Eastern Counties (*continued*). Div. XVIII.—N.-Western Counties.

| | Aberdeen (*continued*). | | | | Moray. | | West Ross. | | East Ross. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Height of Rain-gauge above | Castle Newe. | | Ellon, Tillydesk. | | Elgin Institution. | | Loch Alsh, Inverinate House. | | Cromarty. | | Ardross Castle, Alness. | |
| Ground ..... | 1 ft. 0 in. | | 0 ft. 4 in. | | 0 ft. 6 in. | | 3 ft. 0 in. | | 3 ft. 4 in. | | 1 ft. 0 in. | |
| Sea-level..... | 915 ft. | | 349 ft. | | 33 ft. | | 150 ft. | | 28 ft. | | 450 ft. | |
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| January ..... | ·82 | 4·10 | 1·32 | 2·08 | ·93 | 3·40 | 6·20 | 5·27 | ·38 | 2·61 | ·90 | 4·45 |
| February ... | 2·35 | 3·91 | 3·38 | 3·40 | 1·80 | 2·27 | 5·70 | 1·85 | 3·20 | 1·25 | 5·06 | 1·97 |
| March ..... | 3·35 | 2·90 | 2·20 | 3·12 | 2·35 | 1·51 | 4·70 | ·93 | 2·04 | 1·02 | 4·12 | 2·93 |
| April ..... | 1·24 | ·51 | 1·04 | ·60 | 1·35 | ·77 | 3·45 | 2·35 | ·97 | ·56 | 1·25 | 1·13 |
| May ..... | 2·31 | 2·43 | 2·63 | 1·32 | 2·60 | 1·62 | 3·25 | 3·62 | 1·58 | 1·73 | 1·97 | 2·08 |
| June ..... | 1·71 | ·41 | 1·61 | 1·64 | 1·46 | ·42 | 5·60 | 2·59 | 1·70 | ·15 | 1·98 | ·45 |
| July ..... | 2·10 | 3·86 | 2·56 | 3·78 | 4·13 | 2·71 | 4·50 | 7·25 | 1·08 | 3·15 | 1·67 | 1·61 |
| August ..... | 1·47 | 3·25 | 1·70 | 2·53 | 1·24 | 3·15 | 4·30 | 6·76 | 1·33 | 1·83 | 1·71 | 1·46 |
| September ... | 4·36 | ·34 | 2·91 | ·66 | 3·86 | ·80 | 8·20 | 6·53 | 2·87 | ·80 | 2·20 | 1·03 |
| October ..... | 8·30 | 5·72 | 4·35 | 4·64 | 4·88 | 2·82 | 3·80 | 6·62 | 4·42 | 2·99 | 7·76 | 7·15 |
| ... | 5·70 | 2·68 | 5·93 | 2·60 | 2·70 | 2·48 | 4·85 | 4·47 | 1·82 | 2·08 | 3·20 | 2·50 |
| .. | 2·77 | 3·24 | 3·33 | 1·32 | 2·22 | 1·16 | 7·75 | 8·49 | 1·93 | 1·34 | 3·52 | 2·25 |
| ... | 36·48 | 33·35 | 32·96 | 27·09 | 29·52 | 23·11 | 62·30 | 56·73 | 23·32 | 19·51 | 35·34 | 29·68 |

## SCOTLAND.

| XVI.—East Midland (*continued*). | | Division XVII.—North Eastern Counties. | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Forfar (*continued*). | | Kincardine. | | | | | | | | Aberdeen. | | | |
| broath. | Montrose. | Brechin, The Burn. | | Bogmuir, Fettercairn. | | Banchory House. | | Braemar. | | Aberdeen. | |
| 0 in.<br>5 ft. | 2 ft. 0 in.<br>200 ft. | 0 ft. 6 in.<br>237 ft. | | 0 ft. 3 in.<br>200 ft. | | 0 ft. 4 in.<br>99 ft. | | 0 ft. 9 in.<br>1110 ft. | | 0 ft. 4 in.<br>95 ft. | |
| 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| 2·08 | 1·99 | 5·83 | 3·50 | 3·50 | 2·80 | 3·50 | 1·30 | 3·50 | 1·35 | 3·40 | 1·28 | 2·30 |
| 2·92 | 3·35 | 2·54 | 3·80 | 4·40 | 3·50 | 3·00 | 4·10 | 4·60 | 2·35 | 1·78 | 2·70 | 4·84 |
| 1·33 | 1·69 | ·76 | 2·40 | 2·10 | 2·30 | 2·00 | 2·00 | 2·60 | 2·21 | 1·83 | 2·96 | 2·03 |
| 1·01 | 1·19 | 1·09 | 1·50 | ·70 | 1·60 | ·80 | ·70 | ·30 | ·96 | ·48 | ·99 | ·57 |
| 2·26 | 2·87 | 6·09 | 2·20 | 2·70 | 1·50 | 2·40 | 1·30 | 2·20 | 1·69 | 2·68 | 1·64 | 1·79 |
| ·44 | ·76 | ·38 | 1·50 | ·30 | 1·00 | ·30 | ·50 | ·50 | 2·60 | ·24 | 1·40 | ·87 |
| 1·54 | 1·72 | 4·44 | 1·70 | 3·90 | 1·50 | 2·50 | 1·10 | 2·50 | 1·90 | 3·52 | 2·22 | 2·60 |
| 4·38 | ·84 | 3·96 | ·40 | 3·90 | ·40 | 3·60 | ·30 | 4·10 | 1·10 | 4·18 | 1·31 | 3·45 |
| ·49 | 3·89 | ·42 | 4·70 | ·40 | 3·80 | ·50 | 2·80 | ·30 | 5·14 | ·12 | 2·15 | ·62 |
| 4·11 | 5·50 | 3·50 | 5·20 | 6·20 | 5·70 | 5·70 | 5·00 | 4·50 | 5·16 | 4·23 | 4·41 | 2·75 |
| 3·47 | 2·99 | 3·79 | 5·10 | 3·20 | 5·00 | 3·20 | 4·30 | 4·40 | 5·30 | 2·63 | 3·49 | 3·80 |
| 1·85 | 2·95 | 1·46 | 4·30 | 3·40 | 4·20 | 2·70 | 2·70 | 2·90 | 2·74 | 4·63 | 3·40 | 2·06 |
| 27·88 | 29·94 | 34·26 | 36·30 | 34·70 | 33·30 | 30·20 | 26·10 | 32·40 | 32·50 | 29·72 | 27·95 | 27·68 |

| Division XVIII.—North-Western Counties (*continued*). | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | West Inverness. | | | | | | | | | | | |
| Oransay. | | Raasay. | | Barrahead. | | S. Uist, Uashenish. | | Culloden. | | Island Glass. | | Urquhart, Corrimony. | |
| 0 ft. 6 in.<br>15 ft. | | 3 ft. 0 in.<br>80 ft. | | 3 ft. 0 in.<br>640 ft.? | | 0 ft. 4 in.<br>157 ft.? | | 3 ft. 0 in.<br>104 ft. | | 3 ft. 4 in.<br>50 ft.? | | 0 ft. 4 in.<br>320 ft.? | |
| 864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| n. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| 9·47 | 8·90 | 7·45 | 7·00 | 1·81 | 4·57 | 3·95 | 5·16 | ·45 | 2·72 | 1·55 | 1·04 | 3·00 | 6·30 |
| 6·50 | ·40 | 7·00 | 3·55 | 2·81 | 2·37 | 5·95 | 3·39 | 2·70 | 3·27 | ·74 | 1·46 | 4·30 | 2·00 |
| 4·88 | ·51 | 4·70 | 4·10 | 1·95 | 3·55 | 4·03 | 3·74 | 2·39 | 1·45 | ·89 | 1·67 | 3·00 | 3·20 |
| 4·69 | 2·77 | 3·80 | 1·90 | 1·89 | 1·10 | 3·10 | 1·68 | 1·04 | 1·08 | 1·50 | ·94 | ·70 | 1·10 |
| 3·91 | 3·60 | 2·65 | 4·90 | 1·67 | 3·17 | 1·18 | 2·82 | 1·76 | 1·71 | 1·20 | 1·04 | 1·00 | 2·40 |
| 10·14 | 2·40 | 5·35 | 2·10 | 3·91 | ·95 | 3·15 | 1·31 | 1·67 | ·08 | 2·40 | 1·14 | ·70 | ·00 |
| 5·20 | 2·90 | 4·20 | 3·95 | 1·55 | 2·89 | 1·35 | 2·09 | 1·90 | 5·03 | 1·58 | 1·57 | 1·40 | 3·80 |
| 8·05 | 7·10 | 3·90 | 3·85 | 3·40 | 5·91 | 1·66 | 4·45 | 1·09 | 3·37 | 1·25 | 2·17 | 1·30 | 2·70 |
| 15·38 | 5·65 | 10·00 | 4·10 | 6·65 | 1·69 | 5·36 | 4·03 | 2·73 | ·42 | 2·86 | 1·93 | 6·10 | ·50 |
| 6·61 | 3·55 | 3·55 | 4·05 | 3·03 | 2·95 | 2·18 | 3·89 | 5·10 | 2·28 | 1·05 | 1·60 | 10·80 | 4·40 |
| 7·70 | 4·40 | 5·15 | 5·45 | 3·95 | 2·90 | 4·44 | 2·95 | 1·79 | 1·98 | 1·18 | 1·89 | 4·30 | 3·50 |
| 10·33 | 4·80 | 12·20 | 12·30 | 4·15 | 3·39 | 3·60 | 4·15 | 2·14 | 1·57 | 1·31 | 1·48 | 5·10 | 5·90 |
| 91·86 | 46·98 | 69·95 | 57·25 | 36·77 | 35·44 | 39·95 | 39·66 | 24·76 | 24·96 | 17·51 | 17·93 | 41·70 | 35·80 |

## SCOTLAND.

### Division XIX.—Northern Counties.

| Height of Rain-gauge above Ground ..... Sea-level ..... | Sutherland. Dunrobin Castle. 0 ft. 6 in. 6 ft. | | Sutherland. House of Tongue. 0 ft. 1 in. 33 ft. | | Sutherland. Cape Wrath. 3 ft. 6 in. 355 ft.? | | Caithness. Nosshead. 3 ft. 4 in. 127 ft. | | Caithness. Holburnhead, Thurso. 0 ft. 4 in. 60 ft.? | | Perth... Sterri... 3 ft. 3 i... 72 ft. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| January ..... | ·75 | 4·30 | 1·70 | 5·70 | 2·00 | 5·02 | ·60 | 2·14 | ·60 | 2·22 | 3·... |
| February ... | 4·60 | 2·23 | 12·70 | 1·90 | 4·15 | 2·29 | 2·92 | 1·44 | 4·05 | 2·37 | 3·91 |
| March..... | 3·35 | 2·65 | 4·30 | 6·20 | 2·90 | 2·75 | 3·45 | 2·72 | ·67 | 2·57 | 2·45 |
| April ..... | ·70 | ·52 | ·50 | 1·20 | 1·66 | 1·71 | ·40 | ·68 | ·52 | 1·03 | 1·00 |
| May ..... | 2·00 | ·90 | 2·00 | ·70 | 1·49 | 1·39 | ·97 | ·29 | 1·15 | ·87 | 1·62 |
| June ..... | 1·10 | ·38 | 2·20 | ·30 | 3·61 | 1·64 | 1·60 | ·15 | 1·01 | 1·23 | 1·65 |
| July ..... | 1·45 | 1·84 | 2·20 | 2·00 | 2·70 | 1·80 | 1·57 | 1·92 | ·61 | 1·90 | 1·99 |
| August ..... | 1·08 | 1·76 | 1·20 | 1·70 | 3·52 | 3·84 | 2·26 | ·55 | ·90 | 1·91 | 2·04 |
| September ... | 4·20 | ·81 | 3·90 | 1·10 | 4·97 | 3·05 | 2·60 | ·55 | 1·36 | 2·21 | 2·46 |
| October ..... | 3·83 | 3·60 | 4·60 | 3·50 | 3·06 | 4·38 | 4·88 | 2·05 | 1·90 | 3·95 | 5·60 |
| November ... | 2·80 | 1·00 | 4·80 | 2·40 | 3·66 | 2·72 | 4·61 | 2·18 | 2·10 | 3·12 | 4·83 |
| December ... | 2·30 | 1·07 | 3·60 | 2·20 | 4·47 | 2·21 | 1·37 | ·42 | 3·27 | 1·53 | 2·99 |
| Totals ..... | 28·16 | 21·06 | 43·70 | 28·90 | 38·19 | 32·80 | 27·23 | 15·09 | 18·14 | 24·91 | 31·94 |

### Division XX.—Munster (*continued*). Div. XXI.—Leins...

| Height of Rain-gauge above Ground ..... Sea-level ..... | Waterford. Waterford. 4 ft. 0 in. 60 ft. | | Waterford. Portlaw. 20 ft. 0 in. 50 ft. | | Clare. Killaloe. 5 ft. 0 in. 128 ft. | | Clare. Ennis. 2 ft. 6 in. 35 ft. | | Kilkenny. Kilkenny. 0 ft. 6 in. 200 ft. | | Queen's... Portarlin... 1 ft. 1... 236 ft. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| January ..... | 3·75 | 4·29 | 6·06 | 4·03 | 2·95 | 6·13 | 2·49 | 5·25 | 3·79 | 3·28 | 3·9... |
| February ... | 1·77 | 3·17 | 2·38 | 3·08 | 1·88 | 5·16 | 1·96 | 2·90 | ·83 | 4·18 | 1·15 |
| March.....,... | 3·18 | 1·70 | 3·66 | 2·19 | 2·85 | 3·42 | 2·17 | 2·45 | 2·42 | 2·13 | 3·... |
| April ..... | 1·85 | 1·10 | 1·45 | 1·85 | 1·22 | ·45 | 1·28 | 0·75 | 1·95 | ·94 | 2·... |
| May..... | 1·67 | 4·54 | 1·94 | 5·12 | 1·84 | 5·52 | 1·43 | 3·57 | 2·11 | 3·51 | 3·13 |
| June ..... | 1·20 | ·68 | 2·16 | ·59 | 3·39 | 2·19 | 2·44 | 1·10 | 2·32 | ·87 | 2·12 |
| July..... | 1·73 | 3·62 | 1·28 | 4·40 | 1·64 | 3·54 | ·53 | 1·54 | ·75 | 2·68 | ·79 |
| August ..... | 1·53 | 5·08 | 1·12 | 4·71 | 1·63 | 4·34 | 2·04 | ·51 | 3·31 | 3·32 | 2·30 |
| September ... | 3·23 | ·55 | 3·77 | ·51 | 5·63 | 1·10 | 6·02 | 1·50 | 3·73 | ·88 | 6·23 |
| October ..... | 5·05 | 4·07 | 5·54 | 4·29 | 3·23 | 5·05 | ·10 | 3·62 | 4·46 | 3·39 | 5·... |
| November ... | 4·91 | 6·00 | 6·36 | 8·75 | 6·48 | 5·06 | 5·25 | 5·20 | 5·62 | 2·89 | 6·31 |
| December ... | 4·59 | 6·22 | 4·55 | 7·73 | 2·90 | 4·08 | 2·73 | 3·72 | 3·89 | 2·46 | 4·51 |
| Totals ..... | 34·46 | 41·02 | 40·27 | 47·25 | 35·64 | 46·04 | 28·44 | 32·11 | 35·18 | 30·43 | 43·45 |

SCOTLAND. IRELAND.

| Division XIX.—Northern Counties (*continued*). | | | | | | | | | | Div. XX.—Munster. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Orkney. | | | | Shetland. | | | | | | Cork. | | Kerry. | |
| ur Castle. | | Sandwick Lawn. | | Sumburghead. | | Bressay Manse. | | East Yell. | | Cork, Queen's College. | | Valentia. | |
| ft. 3 in. 50 ft. | | 2 ft. 0 in. 78 ft. | | 3 ft. 4 in. 265 ft.? | | 0 ft. 9 in. 12 ft. | | 3 ft. 0 in. 170 ft. | | 6 ft. 0 in. 65 ft. | | 2 ft. 0 in. 30 ft. | |
| 4. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| 10 | 2·55 | 1·37 | 4·08 | 1·54 | 2·67 | 2·70 | 4·80 | 2·88 | 6·00 | 4·07 | 4·22 | 5·44 | 8·02 |
| 20 | 1·90 | 3·78 | 3·40 | 1·81 | 1·96 | 4·00 | 4·20 | 3·10 | 1·90 | 1·67 | 3·00 | 2·89 | 3·71 |
| 10 | 2·20 | 2·69 | 4·74 | ·99 | 2·44 | 3·20 | 2·60 | 7·76 | 4·88 | 3·24 | 3·82 | 3·96 | 4·19 |
| 10 | 1·10 | 1·23 | 1·47 | 1·38 | ·91 | 1·70 | 2·00 | 1·85 | 1·47 | 1·77 | 1·54 | 1·55 | 1·71 |
| ·50 | 1·25 | 1·88 | 1·90 | 1·05 | 1·01 | 2·80 | 1·60 | 1·74 | 1·68 | 2·44 | 4·36 | 2·51 | 3·54 |
| ·30 | 1·07 | 1·90 | 1·42 | 1·62 | ·58 | 2·00 | ·50 | 3·19 | 1·04 | 2·06 | ·66 | 4·92 | 1·31 |
| ·00 | 2·10 | 1·63 | 1·55 | 1·93 | 1·24 | 3·40 | 2·40 | 2·80 | 1·86 | ·70 | 3·35 | 1·44 | 2·35 |
| ·90 | 3·20 | 2·60 | 2·66 | 2·39 | 1·91 | 3·50 | 2·20 | 3·60 | 3·34 | 1·87 | 4·39 | 3·44 | 6·17 |
| 2·80 | 1·60 | 3·69 | 2·28 | 1·97 | 1·75 | 3·20 | 1·90 | 2·35 | 1·98 | 2·77 | ·85 | 5·32 | 4·11 |
| 5·10 | 4·28 | 3·66 | 4·85 | 2·27 | 1·01 | 4·50 | 2·20 | 5·09 | 4·82 | 4·81 | 3·29 | 2·72 | 8·60 |
| 3·10 | 2·30 | 4·69 | 3·07 | 3·37 | 2·72 | 6·50 | 4·10 | 4·35 | 6·94 | 5·78 | 6·84 | 8·04 | 9·08 |
| 3·55 | 1·90 | 4·16 | 2·79 | 3·58 | 2·27 | 5·50 | 3·60 | 3·60 | 2·18 | 3·43 | 6·69 | 5·39 | 6·30 |
| 77·5 | 25·45 | 33·28 | 34·21 | 23·90 | 20·47 | 43·00 | 32·10 | 42·31 | 38·09 | 34·61 | 43·01 | 47·62 | 59·09 |

| Division XXI.—Leinster (*continued*). | | | | | | | | | | | | Div. XXII. Connaught. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kings Co. | | | | Wicklow. | | Dublin. | | | | | | Galway. | |
| Birr Castle, Parsonstown. | | Tullamore. | | Bray, Fassaroe. | | Black Rock. | | Dublin. | | Glasnevin. | | Gort, Cregg Park. | |
| 0 ft. 3 in. 200 ft. | | 3 ft. 0 in. 235 ft. | | 5 ft. 0 in. 250 ft. | | 29 ft. 0 in. 95 ft. | | 18 ft. 0 in. 42 ft. | | 6 ft. 6 in. 66 ft. | | 3 ft. 0 in. 120 ft. | |
| 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| 1·81 | 3·88 | 1·78 | 2·05 | 3·09 | 4·03 | 1·83 | 3·18 | 2·45 | 2·29 | 1·45 | 1·49 | 2·23 | 4·23 |
| ·68 | 2·71 | ·71 | 2·48 | 1·22 | 4·29 | ·89 | 2·19 | 1·17 | 2·68 | 1·03 | 1·79 | 1·98 | 3·38 |
| 2·64 | 1·80 | 2·41 | 1·98 | 4·12 | 1·83 | 3·03 | 1·21 | 3·51 | 1·94 | 2·58 | 1·15 | 3·10 | 2·58 |
| 1·17 | 1·05 | 1·13 | ·72 | ·46 | 1·85 | ·58 | 1·61 | 1·20 | 1·50 | ·73 | 1·10 | 1·35 | 1·32 |
| 1·65 | 3·69 | 1·15 | 3·36 | 1·38 | 4·82 | 1·78 | 2·89 | 1·70 | 3·92 | 1·59 | 3·12 | 2·07 | 3·44 |
| 3·25 | ·85 | 2·53 | ·87 | 1·63 | ·79 | 1·26 | ·47 | 1·35 | ·70 | 1·14 | ·75 | 2·45 | 1·75 |
| ·81 | 3·19 | ·56 | 2·18 | ·41 | 4·42 | ·59 | 2·71 | 1·06 | 3·62 | ·87 | 2·03 | 1·17 | 5·66 |
| 1·73 | 2·82 | 1·56 | 2·99 | 1·38 | 4·46 | 1·47 | 4·32 | 1·35 | 2·84 | ·92 | 3·95 | 2·02 | 4·15 |
| 3·34 | ·48 | 3·27 | ·29 | 2·01 | ·09 | 1·65 | ·02 | 2·46 | ·11 | 1·59 | ·03 | 5·50 | ·97 |
| 3·75 | 4·03 | 3·94 | 3·66 | 7·24 | 5·38 | 6·44 | 4·13 | 5·65 | 3·74 | 6·13 | 3·35 | 3·29 | 2·89 |
| 4·07 | 4·21 | 3·26 | 3·87 | 5·62 | 6·00 | 4·01 | 3·78 | 4·67 | 3·09 | 3·85 | 2·71 | 6·55 | 3·71 |
| 2·14 | 3·19 | 1·68 | 2·47 | 3·10 | 4·25 | 2·20 | 3·29 | 3·18 | 2·80 | 2·07 | 2·87 | 2·18 | 4·35 |
| 27·04 | 31·90 | 23·98 | 26·92 | 31·66 | 42·21 | 25·73 | 29·80 | 29·75 | 29·23 | 23·95 | 24·34 | 33·89 | 38·43 |

## IRELAND.

| Division XXII.—Connaught (*continued*). | | | | | | | Division XXIII.—Ulster. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Galway (*continued*). | | | Sligo. | | | | Cavan. | | Fermanagh. | | Armagh. | |
| Height of Rain-gauge above Ground ..... Sea-level ..... | Galway, Queen's College. 6 ft. 0 in. 25 ft. | | Doo Castle. 1 ft. 0 in. ..... | | Sligo, Hazlewood. 2 ft. 4 in. 47 ft. | | Red Hills, Belturbet. 0 ft. 9 in. ..... | | Florence Court. 11 ft. 0 in. 300 ft. | | Armagh Observatory 30 ft. 0 in. 238 ft. | |
| | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 18 |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in | in. | in |
| January ..... | 4·62 | 9·01 | 3·04 | 4·65 | 2·70 | 4·16 | 1·68 | 3·28 | 2·69 | 4·09 | 2·51 | 3 |
| February..... | 4·16 | 5·04 | 1·80 | 2·86 | 2·41 | 3·51 | 1·53 | 4·62 | 1·59 | 4·38 | 2·36 | 4 |
| March ..... | 5·33 | 2·54 | 2·97 | 3·28 | 2·09 | 4·74 | 2·34 | 2·84 | 3·17 | 3·18 | 2·74 | 2 |
| April ..... | 2·99 | ·74 | 1·90 | 1·40 | 2·44 | 1·65 | 2·29 | ·78 | 2·07 | 1·10 | 2·07 | |
| May..... | 2·88 | 4·19 | 2·04 | 2·55 | 3·85 | 2·25 | 1.80 | 4·05 | 1·80 | 3·67 | 1·99 | 5 |
| June ..... | 5·41 | 1·26 | 2·84 | 1·33 | 3·87 | ·97 | 2·94 | ·48 | 3·04 | ·61 | 2·69 | |
| July..... | 3·01 | 4·60 | 1·60 | 3·99 | 1·79 | 3·08 | 1·53 | 2·91 | ·84 | 3·05 | 1·84 | 2 |
| August..... | 4·10 | 4·91 | 2·32 | 3·85 | 2·09 | 6·16 | 1·96 | 3·93 | 2·37 | 5·11 | 2·49 | 3 |
| September ... | 7·32 | 2·21 | 4·42 | ·61 | 5·23 | ·89 | 4·19 | ·66 | 2·36 | ·99 | 3·44 | |
| October ..... | 4·88 | 5·91 | 2·19 | 5·61 | 2·31 | 5·69 | 1·56 | 5·92 | 1·30 | 5·85 | 3·10 | 6 |
| November ... | 9·23 | 3·97 | 5·23 | 4·98 | 7·06 | 4·20 | 5·19 | 4·12 | 5·99 | 5·19 | 6·61 | 4 |
| December ... | 4·14 | 4·52 | 1·54 | 4·51 | 1·80 | 4·51 | 2·06 | 3·33 | 2·21 | 5·93 | 2·98 | 3 |
| Totals ..... | 58·07 | 48·90 | 31·89 | 39·62 | 37·64 | 41·81 | 27·07 | 36·92 | 29·43 | 43·15 | 34·81 | 37 |

## EXAMINATION OF RAIN-GAUGES.

As an introduction to the following Tables, and also as calculated materially to avoid continued repetition, it may be well to refer briefly (1) to the objects of this examination, (2) the means adopted to carry it into effect, and (3) to explain the results herein given.

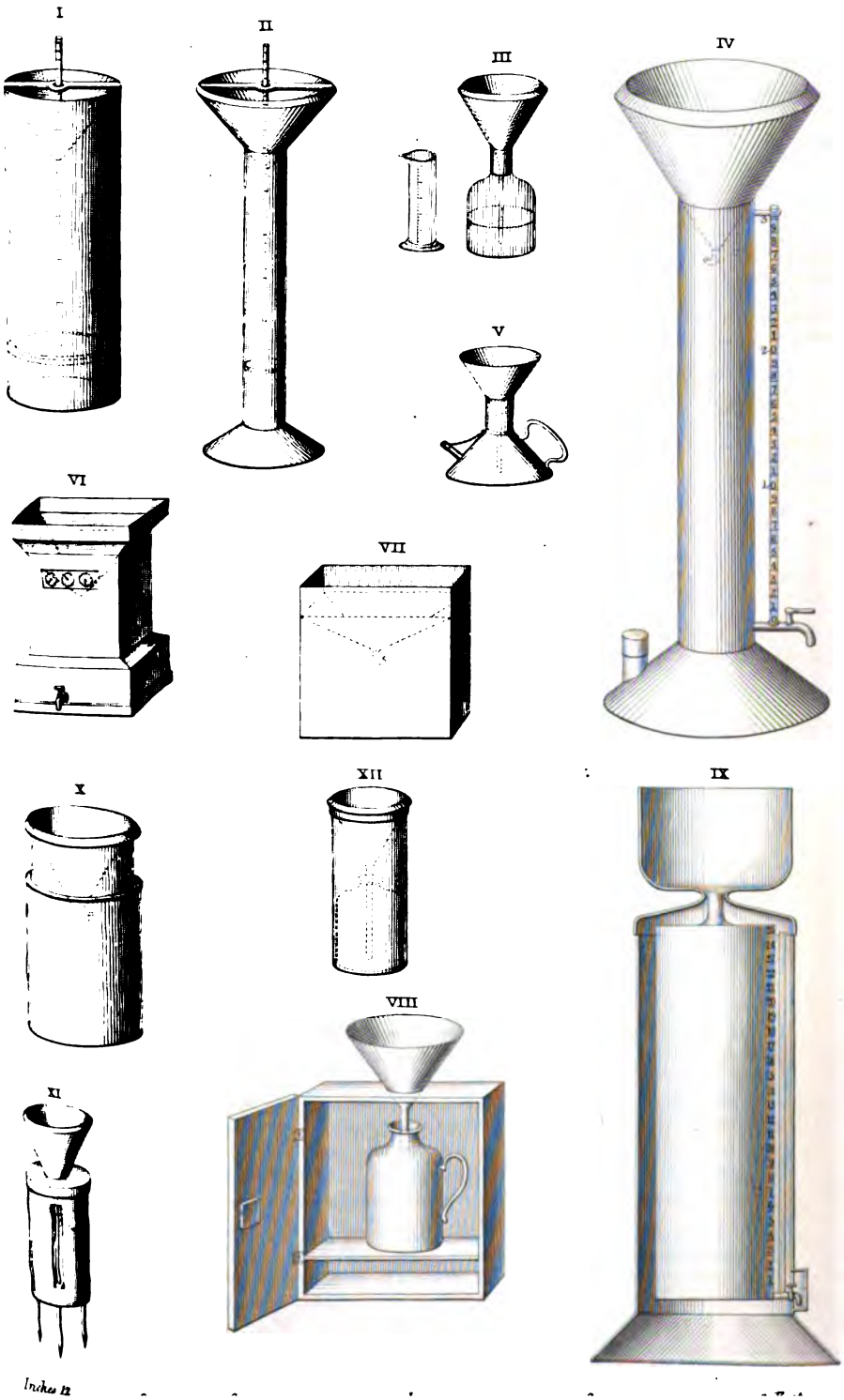
(1) The objects of this examination are principally to ascertain the accuracy of the gauges in actual use, the suitability of their position, the correctness of the mode and time of observing, and generally to advise the observers concerning the proper management of their gauges under all circumstances.

(2) The means adopted simply consist in Mr. Symons's visiting each station, and personally measuring every important element concerned, the details being entered at the time in printed forms prepared for the purpose*.

(3) The result of 166 such examinations in different parts of the British Isles are given in the following Table, in which only two points appear to require any explanation:—(1) That the Roman numerals refer to the gauges in Plate VI., and denote the general form which the gauge *most nearly resembles*, since the varieties of form are so numerous that it would be undesirable to represent each *exactly*. (2) The mode of testing usually consists in filling the glass belonging to the gauge up to various points (called in the Table scale-points, *i. e.* points on the scale); this quantity is then measured in grains, and entered as "grains equivalent to scale-point," then the difference between this observed quantity and that which is due to that

* The following were not measured by Mr. Symons:—Nos. 1 to 12, 56, and 58 to 61.

# Rain gauges in use in 1866.




Inches

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OF
CALIFORNIA.

## IRELAND.

### Division XXIII.—Ulster (*continued*).

| Down. | | | | Antrim. | | Londonderry. | | | | Tyrone. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ltown, ridge. | | Waringstown. | | Antrim. | | Moneydig, Garvagh. | | Londonderry. | | Leckpatrick, Strabane. | | Letterkenny. | |
| . 8 in. 00 ft. | | 0 ft. 4 in. 190 ft. | | 1 ft. 0 in. 150 ft. | | 1 ft. 1 in. 121 ft. | | 0 ft. 6 in. 80 ft. | | 0 ft. 5 in. 260 ft. | | 0 ft. 6 in. 107 ft. | |
| . 1865. | | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. | 1864. | 1865. |
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| | 2·66 | 1·65 | 2·95 | 1·56 | 3·10 | 2·63 | 4·48 | 2·55 | 6·73 | 2·21 | 4·98 | 3·55 | 7·95 |
| 9 | 2·70 | 1·19 | 2·75 | ·79 | 2·90 | 1·86 | 3·87 | 2·60 | 4·00 | 2·72 | 3·30 | 3·62 | 5·03 |
| 5 | 2·24 | 2·11 | 2·25 | 3·53 | 2·05 | 3·58 | 2·77 | 3·79 | 3·40 | 3·18 | 3·40 | 6·56 | 3·56 |
| 9 | ·59 | 2·05 | ·59 | 2·45 | ·52 | 2·27 | 1·27 | 2·60 | 1·34 | 2·58 | 1·55 | 3·01 | ·95 |
| 5 | 4·20 | 2·12 | 3·80 | 1·37 | 3·52 | 2·09 | 3·68 | 2·75 | 2·90 | 2·68 | 2·91 | 1·93 | 2·68 |
| 80 | ·50 | 2·64 | ·54 | 3·67 | ·73 | 4·19 | ·71 | 3·20 | ·66 | 3·49 | ·25 | 4·77 | ·85 |
| 2· | 1·55 | 1·15 | 1·28 | 1·92 | 2·34 | 1·73 | 2·20 | 1·74 | 2·50 | 2·56 | 1·75 | 2·30 | 3·76 |
| ·35 | 2·68 | 2·28 | 3·16 | 2·03 | 3·35 | 2·23 | 6·15 | 2·42 | 5·50 | 1·98 | 5·37 | 3·37 | 5·50 |
| 1·54 | ·30 | 2·21 | ·38 | 3·69 | ·46 | 3·62 | ·56 | 4·10 | ·74 | 4·38 | ·73 | 5·60 | ·85 |
| 1·35 | 6·02 | 1·98 | 4·91 | 3·01 | 4·56 | 1·77 | 4·89 | 3·18 | 4·32 | 2·28 | 5·30 | 3·32 | 7·22 |
| ·47 | 3·55 | 3·93 | 3·65 | 3·82 | 3·71 | 4·20 | 4·00 | 4·75 | 4·50 | 5·17 | 4·81 | 5·91 | 6·58 |
| ·96 | 2·22 | 2·13 | 2·36 | 1·90 | 2·17 | 1·59 | 3·28 | 1·35 | 2·65 | 1·76 | 3·64 | 2·38 | 5·53 |
| 10 | 29·21 | 25·44 | 28·62 | 29·74 | 29·41 | 31·76 | 37·86 | 35·03 | 39·24 | 34·99 | 37·99 | 46·32 | 50·46 |

scale-point of the gauge the area of which is known from the mean diameter, gives the last column, "Error at scale-point." An example will make this clear. Gauge No. I. has a mean diameter of 7·995, therefore 0·1 of an inch should be 1268 grains, but the glass only held 1260 grains, being 8 grains too little, it therefore shows 0·001 too much; that is to say, when rain falls to the depth of 0·100 in. it shows 0·101 in., an error of no practical effect, being less than the ordinary error of observing*.

Concerning this Plate it is necessary to explain that Nos. I. and II. are liable to considerable error if the rods are allowed to rise much above the funnel, as they then intercept rain which would otherwise pass over; they are sometimes tied down to the cross piece, sometimes only dropped in when an observation has to be made. No. VI., Crossley's gauge, registers on the dials by an arrangement of wheelwork, but it is desirable it should (when used) always be provided with a cistern and tap so that the quantity may be measured by a glass, and the clockwork-record thereby checked. Nos. V., VII., VIII., X., XI., and XII. are all provided with glasses similar to No. III., but of course varying in capacity. No. IX. was designed by Mr. Marshall, of Patterdale Hall, for use in the mountains of Cumberland and Westmoreland.

* It may here be noted that though the errors are uniformly worked out to three places of decimals, very much reliance cannot be placed on an error of ·001 in a 5-inch gauge, seeing that it involves the correct reading of a water-surface to one hundredth of a linear inch.

EXAMINATION OF

| Reference number. | Date of examination. | County. | Name of station, owner, and observer. | Construction of gauge. | Maker's name. | Time of reading |
|---|---|---|---|---|---|---|
| | 1862. | | | | | |
| 1. | Aug. 5. | Westmoreland ... | Kendal, S. Marshall, Esq. ..... | VIII. | Mr. S. Marshall... | 9 a.m. |
| 2. | Aug. 6. | Lancashire..... | Holker, Cartmel, Duke of Devonshire, Mr. W. Wilson. | VIII. | Mr. S. Marshall... | 8 a.m. |
| 3. | Aug. 6.<br>Aug. 20. | Lancashire..... | Pitt Farm, Cartmel, Mr. Binyon | VIII. | Mr. S. Marshall... | 9 p.m.<br>of 31st |
| 4. | Aug. 7. | Lancashire..... | Alithwaite, Cartmel, Mr. Nash | III. | Casella ..... | 8 p.m. |
| 5. | Aug. 9. | Lancashire..... | Monk Coniston Park, J. G. Marshall, Esq. | IX. | Marshall & Co.... | 9 a.m.<br>1st. |
| 6. | Aug. 10. | Lancashire..... | Wray Castle, Windermere, Dr. Dawson, Mr. Paisley. | VIII. | Mr. S. Marshall... | 9 a.m. |
| 7. | Aug. 10. | Westmoreland ... | Lesketh How, Ambleside, Dr. J. Davy, F.R.S. | ..... | ..... | 8 a.m. |
| 8. | Aug. 14. | Cumberland .. ... | Borrowdale, Seathwaite, I. Fletcher, Esq. | III. | Potter..... | 9 a.m. |
| 9. | Aug. 16. | Cumberland ..... | Keswick, Mr. J. F. Crosthwaite | VIII. | Mr. S. Marshall... | 9 a.m. |
| 10. | Aug. 16. | Cumberland ..... | Mirehouse, Bassenthwaite, T. S. Spedding, Esq. | III. | ..... | 9 a.m. |

## IN-GAUGES.

| Height of gauge. above ground. | Height of gauge. Above sea-level. | Diameters (that marked M = mean). | Equivalent of water. Scale-point. | Equivalent of water. Grains. | Error at scale-point, specified in previous column. | Remarks on position, &c. | Reference number. |
|---|---|---|---|---|---|---|---|
| in. | feet. | in. | in. | | | | |
| 6 | 149 | 7·95 | ·1 | 1260 | +·001 | In garden S.E. of the house, and about 120 feet from it; it is quite open in all directions. Measuring-glass more than a foot long, but only holds 0·25 in. It is beautifully divided to thousandths. | 1. |
| | | 8·04 | ·2 | 2520 | +·001 | | |
| | | M 7·995 | | | | | |
| 8 | 155 | 8·01 | ·1 | 1255 | +·001 | Gauge stands in the middle of a large garden, quite removed from any object that could interfere with its indications. | 2. |
| | | 8·00 | ·2 | 2510 | +·003 | | |
| | | 8·02 | | | | | |
| | | M 8·010 | | | | | |
| 1 | 170 | 8·00 | ·1 | 1240 | +·003 | Stands in the garden; quite unsheltered. | 3. |
| | | 8·00 | ·2 | 2500 | +·004 | | |
| | | 8·07 | ·3 | 3750 | +·006 | | |
| | | 8·00 | ·4 | 5000 | +·008 | | |
| | | M 8·018 | | | | | |
| 1 0 | 88 | 5·00 | ·2 | 1030 | −·008 | From N.E. to S.S.E. there are shrubs and trees from 8 to 16 ft. high, at distances of 15 to 40 ft. The house (perhaps 30 ft. high) is to W.S.W., at a distance of 40 ft. The gauge may possibly be slightly sheltered by the shrubs. | 4. |
| | | 5·00 | ·3 | 1540 | −·011 | | |
| | | 4·99 | ·5 | 2520 | −·009 | | |
| | | M 4·997 | | | | | |
| 4 11 | 150 | 9·96 | ..... | ..... | ..... | Owing to the peculiar construction of this gauge, it was found impossible to test it. Its position is unexceptionable; fixed in the middle of the park, and free from all obstructions. | 5. |
| | | 10·02 | | | | | |
| | | 10·08 | | | | | |
| | | 10·05 | | | | | |
| | | M 10·027 | | | | | |
| 1 9 | 250 | 8·02 | ·1 | 1250 | +·001 | Gauge stands on a small hill; the trees and castle are too distant to affect it. | 6. |
| | | 7·98 | ·2 | 2510 | +·002 | | |
| | | 8·00 | | | | | |
| | | 7·99 | | | | | |
| | | M 7·998 | | | | | |
| 1 2 | 200 | 8·04 | ·24 | 3000 | +·005 | Gauge on a little rise, having a few trees on the top. In E.S.E. and E.N.E. trees 15 or 20 ft. high are 10 or 20 ft. distant, and in S.S.W. some 20 feet high and only 18 feet off. | 7. |
| | | 8·06 | ·469 | 6000 | correct. | | |
| | | 8·02 | ·708 | 9000 | +·005 | | |
| | | 8·01 | ·942 | 12000 | +·004 | | |
| | | M 8·032 | | | | | |
| 1 0 | 422 | 5·04 | ·1 | 490 | +·001 | Gauge is at the elbow, where the valley bends from about N.E. by N. to S.S.E., with high perpendicular hills on both sides. No small objects of any importance near the gauge. | 8. |
| | | 4·97 | ·2 | 980 | +·003 | | |
| | | 5·03 | ·3 | 1500 | −·002 | | |
| | | 4·99 | ·4 | 1990 | correct. | | |
| | | M 5·007 | ·5 | 2480 | +·001 | | |
| 5 3 | 270 | 8·04 | ·1 | 1230 | +·002 | Gauge very old, and receiver out of shape. Now stands in a timber-yard, but will be moved Jan. 1, 1863, to a better position, same height above sea. [New gauge, started in 1865.] | 9. |
| | | 7·64 | ·2 | 2490 | +·002 | | |
| | | 8·30 | ·3 | 3760 | +·001 | | |
| | | 7·87 | ·4 | 5000 | +·002 | | |
| | | M 7·962 | ·5 | 6320 | −·003 | | |
| 0 5 | 300 | 5·01 | ·1 | 510 | −·003 | Gauge in flower-garden, and quite free from any object that could interfere with its accuracy. From N.N.E. to S.E. mountains rise gradually from the house. | 10. |
| | | 4·99 | ·2 | 1030 | −·007 | | |
| | | 5·00 | ·3 | 1510 | −·005 | | |
| | | M 5·000 | ·4 | 2000 | −·004 | | |
| | | | ·5 | 2510 | −·006 | | |

EXAMINATON OF

| Reference number. | Date of examination. | County. | Name of station, owner, and observer. | Construction of gauge. | Maker's name. | Time of reading. |
|---|---|---|---|---|---|---|
| | 1862. | | | | | |
| 11. | Aug. 22. | Lancashire..... | Heat Bank, R. B. Peacock, Esq. | II. | ..... | 9 a.m. |
| 12. | „ | Lancashire..... | Caton, Rev. A. Christopherson. | III. | Davis, Leeds ..... | Uncer tain. |
| 13. | Aug. 24. | Middlesex ..... | Finchley Road, G. J. Symons, Esq., G. W. Moon, Esq. | X. | Negretti & Zambra | 9 a.m. |
| 14. | „ | Middlesex ..... | Finchley, Upper, G. J. Symons, Esq., G. W. Moon, Esq. | X. | Negretti & Zambra | 9 a.m. |
| 15. | Sept. 21. | Orkney ..... | Sandwick (Lawn Gauge), Rev. C. Clouston. | VIII. | ..... | 9 a.m. |
| 16. | „ | Orkney ..... | Sandwick (North Park Gauge), Rev. C. Clouston. | VIII. | ..... | 9 a.m. |
| 17. | Sept. 22. | Orkney ..... | Kirkwall, Dr. R. B. Baikie, Mr. J. G. Iverack, | I. | ..... | 9 p.m. |
| 18. | Sept. 24. | Aberdeen ..... | Aberdeen, A. Cruickshank, Esq. | I. | ..... | 9 a.m. |
| 19. | „ | Kincardine..... | Banchory House, A. Thomson, Esq., Mr. J. Forrest. | I. | ..... | ..... |
| 20. | Oct. 7. | Cambridge..... | Cambridge Observatory, Prof. Adams, Mr. A. Bowden. | IV. | ..... | ..... |

UNIVERSITY OF CALIFORNIA

## N-GAUGES (*continued*).

| ight of auge. | | Diameters (that marked M = mean). | Equivalent of Water. | | Error at scale-point, specified in previous column. | Remarks on position, &c. | Reference number. |
|---|---|---|---|---|---|---|---|
| e d. | Above sea-level. | | Scale-point. | Grains. | | | |
| | feet. | in. | in. | | | | |
| r | 82 | 12·00 | | | | Gauge placed just over the brow of a small hill, on the N. side. House and a tree are W.S.W., distant 45 ft.; also trees in S.S.E., about 60 ft. off; testing not complete owing to absence of observer. | 11. |
| | | 12·01 | | | | | |
| | | 11·96 | | | | | |
| | | 12·04 | | | | | |
| | | M 12·002 | | | | | |
| | 120 | 4·99 | ·1 | 520 | −·005 | On S.S.W. slope of a small hill, there are at present a few small fruit-trees near it, but they will be moved in the winter. | 12. |
| | | 4·99 | ·2 | 1030 | −·008 | | |
| | | 4·99 | ·3 | 1540 | −·012 | | |
| | | M 4·990 | ·4 | 2030 | −·011 | | |
| | | | ·47 | 2400 | −·016 | | |
| | 270 | 7·95 | ·1 | 1300 | −·004 | House 35 ft. high, 55 ft. W.N.W. of gauge. Walls 7 ft. high in E.S.E., N.N.E., and S.S.W., but not within 18 ft. of gauge. | 13. |
| | | 7·96 | ·2 | 2504 | correct. | | |
| | | 7·95 | ·3 | 3760 | correct. | | |
| | | 7·94 | | | | | |
| | | M 7·950 | | | | | |
| 4 | 306 | 7·97 | ·1 | 1300 | −·004 | On roof of house perfectly exposed, the wind having no obstruction westward for many miles. | 14. |
| | | 7·95 | ·2 | 2500 | +·001 | | |
| | | 7·94 | ·3 | 3780 | −·002 | | |
| | | 7·94 | ·5 | 6270 | correct. | | |
| | | M 7·950 | | | | | |
| 0 | 78 | 11·4 | ·1 | 2650 | −·005 | In vegetable garden, at foot of lawn, sloping gently to the west, about two miles from the sea, between which and the gauge there is no obstruction whatever. | 15. |
| | | 11·1 | ·2 | 5250 | −·008 | | |
| | | 11·3 | ·3 | 7750 | −·007 | | |
| | | 11·3 | ·4 | 10400 | −·012 | | |
| | | M 11·275 | ·5 | 12960 | −·014 | | |
| 6 | 94 | 11·32 | ·1 | 2650 | −·006 | On a slight knoll above the lawn and manse, in a very exposed position. | 16. |
| | | 11·15 | ·2 | 5250 | −·009 | | |
| | | 11·15 | ·3 | 7750 | −·009 | | |
| | | 11·37 | ·4 | 10400 | −·014 | | |
| | | M 11·247 | ·5 | 12960 | −·017 | | |
| 4 | 8 | 3·00 | ·3 | 415 | +·067 | Dr. Baikie's gauge temporarily placed in Mr. Iverach's garden; a 6-foot wall 40 ft. S.W., another 20 ft. N., the house 25 ft. high, 45 ft. E. The proper glass is broken, and an ordinary 2-oz. glass is used instead, 1 oz. being taken = ·30 in. | 17. |
| | | 3·00 | ·6 | 830 | +·134 | | |
| | | 3·00 | | | | | |
| | | 2·99 | | | | | |
| | | M 2·998 | | | | | |
| 4 | 95 | 8·45 | | | | Observer absent and measure inaccessible. Gauge sunk in a grass-plot, rather sheltered, especially on E., where a 5-ft. wall is only 9 ft. distant. | 18. |
| | | 8·45 | | | | | |
| | | 8·45 | | | | | |
| | | 8·45 | | | | | |
| | | M 8·450 | | | | | |
| 4 | 95 | 6·05 | ·1 | | correct. | Float-gauge sunk in a plot of Spergula pilifera. Gauge correct, but if absolutely emptied it shows 0·20 too little. I found that it was sometimes *emptied*, sometimes set to the zero properly. | 19. |
| | | 6·05 | ·2 | | ,, | | |
| | | 6·05 | ·3 | | ,, | | |
| | | 6·10 | ·4 | | ,, | | |
| | | M 6·063 | ·5 | | ,, | | |
| 6 | 85 | 9·35 | ..... | ..... | ..... | Rather an old gauge, and much the worse for repeated repairs, necessitated by its frequent bursting in frosty weather—[a new one has been | 20. |
| | | 9·33 | | | Too leaky to be tested. | | |
| | | 9·29 | | | | | |
| | | 9·35 | | | | | |
| | | M 9·330 | | | | | |

EXAMINATION (

| Reference number. | Date of examination. | County. | Name of station, owner, and observer. | Construction of gauge. | Maker's name. | Time of reading. |
|---|---|---|---|---|---|---|
| | 1862. | | | | | |
| 21. | Oct. 8. | Cambridge..... | Cambridge, Christ's College, Mr. Hays. | IV. | Negretti & Zambra | 2 p. |
| 22. | Oct. 8. | Suffolk ..... | Abbey Gate St., Bury St. Edmunds, Mr. E. Skepper. | III. | ..... | 9 a. |
| 23. | Oct. 9. | Suffolk ..... | Beech Hill, Bury St. Edmunds, H. Turner, Esq. | III. | ..... ..... | daily |
| 24. | Oct. 9. | Suffolk ..... | Botanic Gardens, Bury St. Edmunds. | III. | ..... ..... | monthly. |
| 25. | Oct. 9. | Suffolk ..... | Westley, Bury St. Edmunds, R. Burrell, Esq, | III. | ... ..... ..... | monthly. |
| 26. | Oct. 9. | Suffolk ..... | Oulford, Mr. P. Grieve. | III. | Casella ..... | 8 a. |
| 27. | Oct. 9. | Suffolk ..... | Barton Hall, Sir C. Bunbury, and Mr. Allan. | III. | Casella ..... | 9 a.m |
| 28. | Oct. 9. | Suffolk ..... | Nether Hall, Thurston, Bury St. Edmunds, W. C. Basset, Esq. | V. | Horne & Thornthwaite. | monthly. |
| 29. | Oct. 9. | Suffolk ..... | Nether Hall, Thurston, W. C. Basset, Esq. | III. | Watkins and Hill | ..... |
| 30. | Oct. 9. | Suffolk ..... | Thurston Vicarage, Bury St. Edmunds, Rev. W. Steggall. | VI. | Watkins and Hill | ..... |

## -GAUGES (*continued*).

| ight auge. Above sea-level. | Diameters (that marked M = mean). | Equivalent of water. Scale-point. | Grains. | Error at scale-point, specified in previous column. | Remarks on position, &c. | Reference number. |
|---|---|---|---|---|---|---|
| feet. | in. | in. | | | erected since]. It stands on a grass-plot 100 ft. W. of the Observatory, which may be 30 ft. high. In N.W. and S.W. are shrubs about 5 ft. high and 10 ft. distant. | |
| 32 | ..... | ..... | ..... | ..... | A 12-in. copper gauge, inaccessible, measuring-tube of small diameter, and divided on its own stem; rain not allowed to pass into the tube except at time of measurement. | 21. |
| 240 ? | 6.00 | ·0625 | 420 | +·004 | Gauge on ridge of roof, and well placed, | 22. |
| | 6·02 | ·1875 | 1280 | +·009 | except that there is a chimney in the | |
| | 6·00 | ·25 | 1770 | +·003 | N. 6 ft. distant, and nearly 6 ft. higher | |
| | 6·00 | | | | than the gauge. | |
| | M 6·005 | | | | | |
| 9 136 ? | 6·00 | | | | Glass inaccessible, but said to be iden- | 23. |
| | 6·01 | | | | tical with No. 22. Placed in a flower- | |
| | 5·99 | | | | garden freely exposed. On the gen- | |
| | 6·00 | | | | tle slope of a hill. | |
| | M 6·000 | | | | | |
| 0 130 ? | 6·02 | ·0625 | 420 | +·004 | Well exposed in all directions, near the | 24. |
| | 6·02 | ·1875 | 1280 | +·008 | river, in a very damp situation. | |
| | 6·00 | ·25 | 1770 | +·003 | | |
| | 6·00 | | | | | |
| | M 6·010 | | | | | |
| 6 216 ? | 4·98 | ·1 | 520 | −·005 | Freely exposed in a large garden; pla- | 25. |
| | 4·99 | ·2 | 1020 | −·007 | ced in a large box to protect from | |
| | 5·00 | ·3 | 1510 | −·006 | frost or accidental overthrow. | |
| | 4·98 | ·4 | 2020 | −·009 | | |
| | M 4·987 | ·5 | 2510 | −·009 | | |
| 2 84 ? | 5·00 | ·1 | 510 | −·003 | Gauge perfectly exposed in a very large | 26. |
| | 5·00 | ·2 | 1010 | −·004 | garden. | |
| | 5·00 | ·3 | 1510 | −·004 | | |
| | 5·00 | ·4 | 2010 | −·005 | | |
| | M 5.000 | ·5 | 2520 | −·008 | | |
| 0 145 ? | 5·00 | ·1 | 500 | −·001 | Gauge perfectly exposed on large lawn | 27. |
| | 4·99 | ·2 | 1000 | −·002 | —nothing within 150 ft. save a very | |
| | 5·00 | ·3 | 1500 | −·003 | light iron fence placed round the | |
| | 5·00 | ·4 | 2000 | −·004 | gauge to protect it. | |
| | M 4·998 | ·5 | 2500 | −·005 | | |
| 6 55 ? | 6·05 | ·1 | 920 | correct | Gauge fastened on short stump of a | 28. |
| | 6·05 „ | ·2 | 1800 | +·005 | tree in the centre of the kitchen-gar- | |
| | 6·05 „ | ·3 | 2740 | +·003 | den, quite freely exposed. | |
| | | ·4 | 3620 | +·008 | | |
| | M 6·050 | ·5 | 4550 | +·008 | | |
| 0? 53 ? | 5·00 | ·1 | 500 | −·001 | This gauge has been removed and sup- | 29. |
| | 5·00 | ·2 | 1000 | −·002 | planted by a new one because mea- | |
| | 5·00 | ·3 | 1500 | −·003 | suring-glass broken off at 0·30 in. | |
| | 5·00 | | | | | |
| | M 5·000 | | | | | |
| 0 168 ? | 10·00 | | | | Well placed on lawn, very good ex- | 30. |
| | 10·00 | | | | posure. On December 31st each | |
| | 10·00 | | | | year is taken to pieces by a watch- | |

EXAMINATION OF

| Reference number. | Date of examination. | County. | Name of station, owner, and observer. | Construction of gauge. | Maker's name. | Time of reading. |
|---|---|---|---|---|---|---|
| | 1862. | | | | | |
| 31. | Oct. 10. | Northampton ... | Marholm, Peterborough, Rev. R. S. C. Blacker. | III. | ..... | 9 a. |
| 32. | Oct. 13. | Rutland ..... | Empingham, Mr. W. Fancourt. | II. | Private ..... | dai |
| 33. | Oct. 13. | Lincolnshire ..... | Wytham-on-the-Hill, Bourne, General Johnson. | II. | ..... | monthly. |
| 34. | Oct. 13. | Lincolnshire ..... | Greatford Hall, Capt. Peacock | II. | Casella ..... | monthly. |
| 35. | Oct. 14. | Leicestershire ... | Belvoir Castle, Grantham, W. Ingram, Esq. | X. | Negretti and Zambra. | 9 a. |
| 36. | Oct. 15. | Lincolnshire ..... | Grantham, J. W. Jeans, Esq. ... | X. | ..... | 9 a. |
| 37. | Oct. 16. | York ..... | Wheldrake, Rev. R. B. Cooke ... | III. | ..... | Satur day |

## RAIN-GAUGES (*continued*).

| ght of uge. Above sea-level. | Diameters (that marked M = mean). | Equivalents of water. Scale-point. | Equivalents of water. Grains. | Error at scale-point, specified in previous column. | Remarks on position, &c. | Reference number. |
|---|---|---|---|---|---|---|
| feet. | in. | in. | | | | |
| | 10·00 | | | | maker, carefully cleaned, and replaced. | |
| | M 10·000 | | | | | |
| 108 | 5·05 | ..... | ..... | ..... | Position good, well exposed. On visiting this gauge, found that the measuring-glass had been entirely destroyed a short time previously; graduated a glass roughly for temporary use, and ordered one for the above diameter to be sent to Mr. B. immediately. | 31. |
| | 5·05 | | | | | |
| | 5·05 | | | | | |
| | 5·05 | | | | | |
| | M 5·050 | | | | | |
| 220 ? | 6·00 sq. | ..... | ..... | ..... | A bad gauge badly placed, the house 30 feet high, being only 15 feet S.E. of the gauge. The rim of gauge, instead of being knife-edged, is 0·04 in. thick; the float is a large bung. | 32. |
| | 6·05 „ | | | | | |
| | 6·00 | | | | | |
| | 5·95 | | | | | |
| | M 6·000 | | | | | |
| | | | | | Having found the gauge standing at 1·15 in., added 500 grs., it showed 1·17; added 1000 grs., it showed 1·20; added 1000 grs., it showed 1·30; added 1000 grs., it showed 1·40; added 1000 grs., it showed 1·50; added 1000 grs., it showed 1·60; added 1000 grs., it showed 1·71; added 1000 grs., it showed 1·81; added 1000 grs., it showed 1·92; added 1000 grs., it showed 2·02; added 1000 grs., it showed 2·11. From the bad position and bad construction of the gauge, the observations, extending over 30 years, are evidently useless. | |
| 167 ? | 6·18 | ·10 | 1000 | −·032 | A very old metal float-gauge, freely exposed, except to W., where there is an apple-tree, 30 ft. distant and 20 ft. high. | 33. |
| | 6·20 | ·21 | 2000 | −·054 | | |
| | 6·18 | ·33 | 3000 | −·066 | | |
| | 6·16 | ·44 | 4000 | −·088 | | |
| | M 6·180 | | | | | |
| 32 ? | 5·00 | ..... | ..... | ..... | Perfectly open situation, on a very fine lawn. Glass not properly tested, but believed to be correct. | 34. |
| | 5·00 | | | | | |
| | 5·00 | | | | | |
| | 5·01 | | | | | |
| | M 5·003 | | | | | |
| 237 ? | 8·00 | ·1 | 1270 | correct. | In the gardens below the castle; perfectly exposed. | 35. |
| | 7·98 | ·2 | 2520 | +·001 | | |
| | 8·02 | ·3 | 3830 | −·002 | | |
| | 8·00 | ·35 | 4470 | −·001 | | |
| | M 8·000 | | | | | |
| 179 | 8·00 | ·302 | 3900 | −·005 | In small garden at rear of house. It is more or less sheltered from all points, but not seriously from any. | 36. |
| | 7·95 | ·56 | 7050 | +·005 | | |
| | 8·07 | | | | | |
| | 8·00 | | | | | |
| | M 8·005 | | | | | |
| 36 | 6·35 | ·1 | 850 | −·005 | In kitchen-garden, quite exposed. | 37. |
| | 6·37 | ·2 | 1700 | −·011 | | |
| | 6·37 | ·3 | 2510 | −·012 | | |
| | 6·40 | ·4 | 3360 | −·017 | | |
| | M 6·372 | | | | | |

EXAMINATION O

| Reference number. | Date of examination. | County. | Name of station, owner, and observer. | Construction of gauge. | Maker's name. | Time of reading. |
|---|---|---|---|---|---|---|
| | 1862. | | | | | |
| 38. | Oct. 17. | York ..... | Holme on Spalding Moor, G. Dunn, Esq. | III. | Davis, of Leeds ... | 9 p.m |
| 39. | Oct. 20. | York ..... | Scarborough, Mr. Roberts ..... | X. | Negretti & Zambra | 9 a.m |
| 40. | Oct. 21. | York ..... | Old Malton, H. Hurtley, Esq.... | VII. | ..... | ... |
| 41. | Oct. 23. | York ..... | York, Bootham, J. Ford, Esq.. | III. | Casella ..... | 9 a.m |
| 42. | Oct. 24. | York ..... | Harrogate, Dr. Bainbridge ..... | X. | Negretti & Zambra | 9 a.m |
| 43. | Oct. 24. | York ..... | Leeds, Holbeck, Messrs. Marshall & Co. | IX. | Messrs. Marshall & Co. | monthly. |
| 44. | Oct. 24. | York ..... | Leeds, Manor Road, Holbeck, Leeds Water-works. | VI. | ..... | daily |
| 45. | Oct. 24. | York ..... | Bradford, Horton Hall, E. Hailstone, Esq. | X. | Negretti & Zambra | ..... |
| 46. | Oct. 25. | York ..... | Well Head, Halifax, J. Waterhouse, Esq. | I. | ..... | monthly. |
| 47. | Oct. 25. | York ..... | Wakefield, W. R. Milner, Esq. | VIII. | Mr. Milner ..... | daily |

I-GAUGES (*continued*).

| ight of auge. | Above sea-level. | Diameter (that marked M = mean). | Equivalents of water. Scale-point. | Equivalents of water. Grains. | Error at scale-point, specified in previous column. | Remarks on position, &c. | Reference number. |
|---|---|---|---|---|---|---|---|
| n. | feet. | in. | in. | | | | |
| 6 | 32 | 5·00 | ·1 | 530 | −·007 | Neither trees nor buildings within a considerable distance. Gauge is thoroughly exposed on a frame, elevating it to the above height. Flat country all round. | 38. |
| | | 5·00 | ·2 | 1020 | −·006 | | |
| | | 5·00 | ·3 | 1505 | −·003 | | |
| | | 5·00 | ·4 | 1980 | correct. | | |
| | | M 5·000 | ·5 | 2490 | −·002 | | |
| 6 | 96 | 7·97 | ·1 | 1220 | +·003 | Position very unsatisfactory, in a confined back yard, sure to catch drippings from a tree in N.E.; had it moved a few feet as being better, but still very objectionable. | 39. |
| | | 7·95 | ·2 | 2480 | +·002 | | |
| | | 7·90 | ·3 | 3700 | +·005 | | |
| | | 8·00 | | | | | |
| | | M 7·955 | | | | | |
| o | 61 | 10·00 | ·1 | 2520 | correct. | Gauge in a large garden, quite exposed. | 40. |
| | | 10·08 | ·2 | 5010 | +·002 | | |
| | | 9·92 | ·3 | 7720 | −·006 | | |
| | | 10·00 | | | | | |
| | | M 10·000 | | | | | |
| 6 | 50 | 5·00 | ·1 | 502 | −·001 | Gauge kept at the Friends' school, on a very large lawn, and well exposed. Glasses often broken and fresh ones bought. | 41. |
| | | 5·01 | ·2 | 1000 | −·002 | | |
| | | 5·00 | ·4 | 2000 | −·003 | | |
| | | 5·00 | | | | | |
| | | M 5·002 | | | | | |
| 6 | 420 | 8·00 | ·1 | 1220 | +·004 | Gauge in garden of a house, said to be in High Harrogate, but certainly not in highest part thereof. Well exposed. | 42. |
| | | 8·02 | ·2 | 2450 | +·006 | | |
| | | 7·97 | | | | | |
| | | 7·95 | | | | | |
| | | M 7·985 | | | | | |
| o | 127 | 9·95 | ..... | ..... | ..... | Fastened to a stone slab on the roof of the factory, but as its area is 2 *acres*, the height above ground is measured to the turf, wherewith the roof is covered, and not to the street. The ground level is 95 ft., the height of the factory 28 ft., and of the gauge 4 ft. | 43. |
| | | 9·98 | | | | | |
| | | 10·05 | | | | | |
| | | 10·00 | | | | | |
| | | M 9·995 | | | | | |
| evel. | 95 | 10·05 | ..... | ..... | ..... | Sufficiently exposed; sunk in a pit 6 ft. square at top, sides formed with flagstones, sloping at 40°; gauge stands in the middle, its top level with the ground. | 44. |
| | | 9·95 | | | | | |
| | | 10·00 | | | | | |
| | | 10·00 | | | | | |
| | | M 10·000 | | | | | |
| 7 | 496 | 8·00 | ..... | ..... | ..... | Freely exposed; there are conservatories to the E. about 40 ft. distant, but only about 10 ft. high. Glass not accessible. Very hilly. | 45. |
| | | 8·01 | | | | | |
| | | 7·96 | | | | | |
| | | 8·00 | | | | | |
| | | M 7·993 | | | | | |
| 11 | 487 | 11·95 | ..... | ..... | ..... | Gauge on slope of lawn, quite open to S.W. Scale-rod measured at several points, and appeared correct. Cylinder also true size at the places measured. [Since reported to give different results from a new gauge placed near it. Perhaps this one has been stretched by frost.] | 46. |
| | | 11·90 | | | | | |
| | | 11·95 | | | | | |
| | | 12·05 | | | | | |
| | | M 11·962 | | | | | |
| 4 o | 115 | 10·00[sq] | ·1 | 2530 | correct. | In the garden of the prison; very well placed. | 47. |
| | | 10·00 „ | ·2 | 5070 | −·001 | | |
| | | 10·02 „ | | | | | |

EXAMINATION OF

| Reference number. | Date of examination. | County. | Name of station, owner, and observer. | Construction of gauge. | Maker's name. | Time of reading. |
|---|---|---|---|---|---|---|
| | 1862. | | | | | |
| 48. | Oct. 27. | York ..... | Huggate, Pocklington, Rev. T. Rankine. | VII. | ..... | ..... |
| 49. | Oct. 27. | York ..... | Middleton, Beverley, Rev. H. D. Blanchard. | III. | Casella ..... | monthly. |
| 50. | Oct. 28. | York ..... | 7 York Parade, Beverley Road, Hull, J. Smith. Jun., Esq. | X. | Negretti & Zambra | daily. |
| 51. | Oct. 28. | York ..... | Patrington Flax Works ..... | IX. | Messrs. Marshall and Co. | monthly. |
| | 1863. | | | | | |
| 52. | April 6. | Sussex ..... | 39 Tower, Leonards-on-Sea, J. C. Savery, Esq. | III. | Private ..... | ..... |
| 53. | April 6. | Sussex ..... | Marina, Leonards-on-Sea, J. C. Savery, Esq. | III. | Casella ..... | daily. |
| 54. | April 6. | Sussex ..... | Bleak House, Hastings (Old gauge) Mr. J. Banks. | II. | Newman..... | daily. |
| 55. | April 6. | Sussex ..... | Fairlight, J. Rock, Esq. ..... | X. | Negretti & Zambra | daily. |
| 56. | April 8. | Kent ..... | West Wickham, Rev. J. T. Austen. | ..... | ..... | daily. |
| 57. | June 12. | Middlesex ..... | Colney Hatch, Mr. Rose ..... | X. | Negretti & Zambra | 10 & 4 daily. |

## GAUGES (*continued*).

| ht of ge. Above sea-level. | Diameters (that marked M = mean). | Equivalents of water. Scale-point. | Equivalents of water. Grains. | Error at scale-point, specified in previous column. | Remarks on position, &c. | Reference number. |
|---|---|---|---|---|---|---|
| feet. | in. | in. | | | | |
| | 10·01 | | | | | |
| | M 10·008 | | | | | |
| 550 | 10·03 | ..... | ..... | ..... | Bad gauge, badly placed. Mr. Rankine had no measure except a scale of inches, halves, and quarters, painted on a box into which the water was poured. A shrub, nearly a foot higher than the gauge, grew close to it and overhung it, and about 15 feet to E. there was a tree 20 feet high. Observations useless. | 48. |
| | 9·98 „ | | | | | |
| | 10·00 „ | | | | | |
| | 9·98 „ | | | | | |
| | M 9·997 | | | | | |
| 150 | 5·03 | ·1 | 500 | correct | Freely exposed in kitchen-garden. | 49. |
| | 5·00 | ·2 | 1000 | correct | | |
| | 5·05 | ·3 | 1510 | −·002 | | |
| | 5·00 | ·5 | 2530 | −·006 | | |
| | M 5·020 | | | | | |
| 11 | 8·00 | ·1 | 1230 | +·003 | Rather sheltered, house 30 feet high, being scarcely 30 feet distant in N.E. | 50. |
| | 7·98 | ·2 | 2470 | +·005 | | |
| | 8·02 | ·4 | 5090 | −·001 | | |
| | 8·00 | ·5 | 6300 | +·004 | | |
| | M 8·000 | | | | | |
| 32 | 10·02 | ..... | ..... | ..... | Not tested for same reason as No. 5. Gauge in flower-garden, 150 feet from house or nearest tree. Level ground for miles; but a ditch near gauge. | 51. |
| | 9·98 | | | | | |
| | 10·00 | | | | | |
| | 9·97 | | | | | |
| | M 9·992 | | | | | |
| 11 | 5·00 | ·1 | 500 | −·001 | In the garden of Martello Tower, No. 39; quite exposed. About 100 yards from high-water line. | 52. |
| | 4·98 | ·5 | 2510 | −·006 | | |
| | 5·01 | | | | | |
| | 5·00 | | | | | |
| | M 4·998 | | | | | |
| 31 | 5·00 | ·1 | 500 | −·001 | In yard at back of Marina; very much sheltered by buildings on S.E., S., and S.W. | 53. |
| | 5·02 | ·5 | 2510 | −·005 | | |
| | 5·01 | | | | | |
| | 5·00 | | | | | |
| | M 5·007 | | | | | |
| 80 | 12·00 | ·1 | 3000 | −·006 | On the slope of a steep hill facing S.W. House 20 feet high, 10 feet to N.E., all else quite open. | 54. |
| | 12·10 | ·21 | 6000 | −·003 | | |
| | 11·70 | ·31 | 9000 | −·009 | | |
| | 11·90 | | | | | |
| | M 11·925 | | | | | |
| 500 | 8·02 | ·1 | 1300 | −·002 | Very fair position, on S. slope of the hill; house 25 feet high, 30 feet to N. | 55. |
| | 7·98 | ·3 | 3880 | −·005 | | |
| | 8·01 | | | | | |
| | 8·00 | | | | | |
| | M 8·003 | | | | | |
| 380 | 12·15 | ..... | ..... | ..... | Freely exposed, in kitchen-garden, on the W. slope of a small hill, not far from its top. | 56. |
| | 12·09 | | | | | |
| | 12·10 | | | | | |
| | 12·16 | | | | | |
| | M 12·125 | | | | | |
| 264 | 8·00 | ·1 | 1300 | −·003 | On sloping roof of asylum facing S.W., in which direction, however, there is a chimney about 20 ft. distant and | 57. |
| | 7·95 | ·2 | 2540 | −·001 | | |
| | 8·03 | ·3 | 3830 | −·002 | | |

EXAMINATION

| Reference number. | Date of examination. | County. | Name of station, owner, and observer. | Construction of gauge. | Maker's name. | Time of |
|---|---|---|---|---|---|---|
| | 1863. | | | | | |
| 58. | July 27. | Kent ..... | Chartwell, Westerham, J. C. Colquhoun, Esq. | III. | Casella ..... | Sa da |
| 59. | July 27. | Kent ..... | River Hill, Sevenoaks, J. Rogers, Esq. | ..... | Knight ..... | da |
| 60. | Aug. 4. | Antrim ..... | Linen Hall, Belfast, Mr. Stewart. | IV. | ..... | 9 |
| 61. | Aug. 4. | Antrim ..... | Queen's College, Belfast, Mr. J. Bell | IV. | ..... | |
| 62. | Aug. 31. | Northumberland. | Rosella Place, N. Shields, R. Spence, Esq. | X. | Negretti & Zambra | 9 a. |
| 63. | Sept. 2. | Durham..... | Sunderland, West Hendon, T. W. Backhouse, Esq. | ..... | Dr. Ogden..... | |
| 64. | Sept. 2. | Durham..... | Hendon Hill, Sunderland, J. W. Mounsey, Esq. | III. | ..... | 8 a. |
| 65. | Sept. 2. | Durham..... | Field House, Sunderland, Rev. G. Iliff. | VII. | Private ..... | 8 a. |
| 66. | Sept. 9. | Devon..... | Plymouth, Saltram Gardens, Mr. J. Snow. | III. | ..... | week |
| 67. | Sept. 9. | Devon..... | Plymouth, Ridgeway, Miss B. T. Phillips. | III. | ..... | |

GAUGES (*continued*).

| ıt of ge. Above sea-level. | Diameters (that marked M = mean). | Equivalents of water. Scale-point. | Equivalents of water. Grains. | Error at scale-point, specified in previous column. | Remarks on position, &c. | Reference number. |
|---|---|---|---|---|---|---|
| feet. | in. | in. | | | | |
| | 7·98 | ·4 | 5040 | −·002 | 15 ft. higher than the gauge. Gauge about 1 ft. above slates. | |
| | M 7·990 | ·5 | 6300 | −·002 | | |
| 500? | 5·02 | ·1 | 500 | −·001 | Some trees W. of gauge, but not near enough to influence the amount collected. It is placed on face of a hill sloping to E. | 58. |
| | 4·98 | ·2 | 1000 | −·002 | | |
| | 5·00 | ·3 | 1510 | −·004 | | |
| | M 5·000 | ·4 | 1980 | +·001 | | |
| 520 | 4·98 | ·2 | 1000? | −·003 | Funnel fixed about 1 ft. above the garden wall: rain runs down a pipe into a graduated glass receiver. | 59. |
| | 4·99 | ·3 | 1440 | +·008 | | |
| | M 4·985 | ·5 | 2460 | correct. | | |
| | | 1·0 | 4920 | +·002 | | |
| 24 | 11·28 | ·05 | 1250 | correct. | Quite unsheltered. | 60. |
| | 11·29 | ·1 | 2500 | +·001 | | |
| | M 11·285 | | | | | |
| 58 | 11·29 | ·05 | 1240 | +·001 | Formerly stood E. of the college buildings, 9 ft. above ground, but having been intentionally damaged, was removed about two months since to the S., where it now stands, 7 ft. 1 in. above ground; it will finally be erected on a stone pier 9 ft. 3 in. above ground. | 61. |
| | 11·35 | ·1 | 2500 | +·001 | | |
| | 11·24 | | | | | |
| | M 11·293 | | | | | |
| 124 | 7·98 | ·1 | 1200 | +·005 | In vegetable garden, more sheltered by fruit-trees than is desirable. | 62. |
| | 8·02 | ·2 | 2480 | +·004 | | |
| | 7·95 | ·3 | 3760 | +·002 | | |
| | 7·96 | ·4 | 5100 | −·004 | | |
| | M 7·978 | ·5 | 6280 | +·003 | | |
| 126? | 2·1 | ·5 | 440 | −·003 | An extraordinary gauge, consisting of a stout glass tube about a foot long and half an inch internal diameter, opened out at the top to a cylinder 2·1 inches in diameter; the divisions are on the tube; the whole is of glass, and there is no provision against frost or evaporation. Position good. | 63. |
| | 2·1 | 1·0 | 880 | −·006 | | |
| | M 2·100 | | | | | |
| 150 | 4·97 | ·1 | 510 | −·004 | Very near to No. 63 (the grounds adjoin). Position very good. | 64. |
| | 4·95 | ·2 | 1010 | −·006 | | |
| | 4·98 | ·5 | 2540 | −·019 | | |
| | 4·97 | | | | | |
| | M 4·968 | | | | | |
| 98 | 9·95 | ·05 | 1260 | −·001 | In kitchen-garden of Field House, subsequently called "The Hall." | 65. |
| | 10·00 | ·1 | 2520 | −·001 | | |
| | 9·85 | | | | | |
| | 9·90 | | | | | |
| | M 9·925 | | | | | |
| 96 | 5·00 | ·1 | 500 | −·001 | Well exposed; but being so close to the ground, recommended that moss or short cut turf be put round it to prevent splashing. | 66. |
| | 4·97 | ·3 | 1500 | −·004 | | |
| | 4·99 | ·4 | 1980 | −·001 | | |
| | 5·00 | ·5 | 2490 | −·004 | | |
| | M 4·990 | | | | | |
| 116 | 5·01 | ·1 | 510 | −·002 | Well placed, on grass plot, but rather too near an apple-tree; suggested its being moved a few feet. | 67. |
| | 4·99 | ·2 | 1000 | −·001 | | |
| | 5·03 | ·3 | 1500 | −·001 | | |
| | 5·02 | ·5 | 2480 | +·002 | | |

EXAMINATION

| Reference number. | Date of examination. | County. | Name of station, owner, and observer. | Construction of gauge. | Maker's name. | Time of |
|---|---|---|---|---|---|---|
| | 1863. | | | | | |
| 68. | Sept. 9. | Devon..... | Plympton, Goodamoor, H. H. Treby, Esq. | III. | ..... | 9 |
| 69. | Sept. 10. | Devon..... | Dartmoor, Morley Clay Works, W. Martin, Esq. | III. | ..... | ..... |
| 70. | Sept. 10. | Devon..... | Dartmoor, Prison Reservoir, Mr. H. Watts. | III. | ..... | 9 |
| 71. | Sept. 10. | Devon..... | Dartmoor, North Hessary Tor, Mr. H. Watts. | III. | ..... | mon ly. |
| 72. | Sept. 11. | Devon..... | Milton Abbot, Edgecumb, H. Clarke, Esq. | III. | ..... | wee |
| 73. | Sept. 11. | Devon..... | Milton Abbot, Endaleigh Gardens, Mr. Cornelius. | III. | ..... | ..... |
| 74. | Sept. 12. | Devon ..... | Plymouth, Ham, Rev. C. Trelawny. | See remarks. | ..... | dail |

## -GAUGES (*continued*).

| ht of ige. Above sea-level. | Diameters (that marked M = mean). | Equivalents of water. Scale-point. | Equivalents of water. Grains. | Error at scale-point, specified in previous column. | Remarks on position, &c. | Reference number. |
|---|---|---|---|---|---|---|
| feet. | in. | in. | | | | |
| | M 5·012 | ·6 | 2950 | +·008 | | |
| 580 | 5·01 | ·1 | 500 | −·001 | In grass plot, in kitchen-garden; very well placed. | 68. |
| | 5·00 | ·2 | 1000 | −·002 | | |
| | 4·99 | ·3 | 1490 | correct. | The second set of readings are from a large glass, not generally used. | |
| | 5·00 | ·5 | 2480 | correct. | | |
| | M 5·000 | ·6 | 2950 | +·005 | | |
| | | ·1 | 500 | −·001 | | |
| | | ·2 | 960 | +·006 | | |
| | | ·3 | 1420 | +·015 | | |
| | | ·4 | 1920 | +·013 | | |
| | | ·5 | 2500 | −·004 | | |
| | | ·6 | 2900 | +·015 | | |
| | | ·8 | 3950 | +·004 | | |
| | | 1·0 | 4950 | +·002 | | |
| 900 | 5·03 | ·1 | 500 | correct. | On lawn, fully exposed, except to N.W., where the house, 20 feet high, is nearly 50 feet distant. | 69. |
| | 4·98 | ·2 | 1000 | −·001 | | |
| | 5·00 | ·5 | 2430 | +·011 | | |
| | 5·02 | 1·0 | 4850 | +·024 | | |
| | M 5·007 | | | | | |
| 1400 | 5·00 | ·1 | 495 | correct. | Placed near the lower reservoirs, on the E. slope, and nearly at the foot of North Hessary Tor. It is about 100 feet W. of the prison, fully exposed, and about 20 feet higher than the ground on which the prison stands. | 70. |
| | 5·02 | ·3 | 1440 | +·010 | | |
| | 4·98 | ·5 | 2480 | correct. | | |
| | 5·01 | 1·0 | 4940 | +·004 | | |
| | M 5·002 | | | | | |
| 1596 | 5·00 | ·1 | 495 | +·001 | Nearly at the top of the hill, about ½ of a mile N.W. of No. 70. | 71. |
| | 5·00 | ·3 | 1440 | +·011 | | |
| | 5·04 | ·5 | 2480 | +·002 | | |
| | 5·00 | 1·0 | 4940 | +·008 | | |
| | M 5·010 | | | | | |
| 160? | 5·00 | ·1 | 500 | −·001 | On slope of a hill facing S., sufficiently exposed; at foot of the hill (20 feet below the gauge) is a small surface of running water. | 72. |
| | 5·00 | ·2 | 1000 | −·002 | | |
| | 5·00 | ·3 | 1500 | −·003 | | |
| | 5·01 | ·4 | 2000 | −·003 | | |
| | M 5·002 | ·5 | 2500 | −·004 | | |
| 180? | 5·00 | ·1 | 500 | −·001 | Gauge well placed, in a level part of the kitchen-gardens. | 73. |
| | 4·99 | ·2 | 1000 | −·002 | | |
| | 5·01 | ·3 | 1500 | −·003 | | |
| | 5·00 | ·4 | 2000 | −·003 | | |
| | M 5·000 | ·5 | 2500 | −·004 | | |
| 94 | 6·75 | ·1 | 1200 | −·035 | A very old established, but also a very unusual gauge, consisting essentially of a catching apparatus, and a separate one for measuring; the former may be described as Fig. X. fixed on a dwarf post, and provided with a tap for drawing off the water into the measuring-apparatus; a cylinder about 2 inches diameter in which floats a bung carrying a divided rod; a constant correction for "sinkage" is included in the above tabu- | 74. |
| | 6·70 | ·2 | 2050 | −·030 | | |
| | 6·70 | ·3 | 2900 | −·026 | | |
| | 6·65 | ·4 | 3900 | −·038 | | |
| | M 6·700 | | | | | |

EXAMINATION

| Reference number. | Date of examination. | County. | Name of station, owner, and observer. | Construction of gauge. | Maker's name. | Plane of |
|---|---|---|---|---|---|---|
| | 1863. | | | | | |
| 75. | Sept. 12. | Devon | Ivybridge, Torrhill, J. Widdicomb, Esq. | III. | | |
| 76. | Sept. 14. | Devon | Torquay, Woodfield, E. Vivian, Esq. | X. | Negretti & Zambra | |
| 77. | Sept. 14. | Devon | Newton Bushel, High Wick, Dr. Barham. | VIII. | | do |
| 78. | Sept. 14. | Devon | Bovey Tracey, John Divett, Esq. | III. | Knight | |
| 79. | Sept. 15. | Devon | Teignmouth, W. C. Lake, Esq. | X. | Negretti & Zambra | |
| 80. | Sept. 15. | Devon | Teignmouth, W. C. Lake, Esq. | III. | | |
| 81. | Sept. 15. | Devon | Teignmouth, Westbrook, Miss K. T. Clark. | III. | | do |
| 82. | Sept. 15. | Devon | Dawlish, Charlton Villa, P. J. Margary, Esq. | III. | | San do |
| 83. | Sept. 16. | Devon | Exeter, Pennsylvania, G. Kennaway, Esq. | III. | Amateur | |
| 84. | Sept. 16. | Devon | Exeter, Albert Terrace, W. Vicary, Esq. | X. | Negretti & Zambra | 9 a.1 |
| 85. | Sept. 16. | Devon | Exeter, Albert Terrace, W. Vicary, Esq. | X. | Negretti & Zambra | |

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GAUGES (*continued*).

| of e. Above sea-level | Diameters (that marked M = mean.) | Equivalents of water. Scale-point. | Equivalents of water. Grains. | Error at scale-point, specified in previous column. | Remarks on position, &c. | Reference number. |
|---|---|---|---|---|---|---|
| feet. | in. | in. | | | lated errors, which the said correction of ·02 increases. | |
| 270 | 5·02 | ·1 | 510 | −·003 | In terraced garden, 3 feet from the 5-feet fall of an E. and W. wall. House 20 feet high, about 20 feet N. of gauge. | 75. |
| | 5·00 | ·2 | 1020 | −·006 | | |
| | 4·98 | ·3 | 1580 | −·019 | | |
| | 5·00 | ·4 | 2080 | −·020 | | |
| | M 5·000 | ·5 | 2580 | −·020 | [Correct glass forwarded 17 Nov. 1863.] | |
| 150 | 8·00 | ·09 | 1230 | −·007 | Funnel very much out of shape, had been much battered. Position not good, on a steep declivity facing S.W. Another gauge (inaccessible) on roof. | 76. |
| | 7·81 | ·2 | 2640 | −·008 | | |
| | 8·16 | ·465 | 6000 | −·008 | | |
| | 8·02 | | | | | |
| | M 7·998 | | | | | |
| 250? | 5·00 | 1 c. in. | 260 | −·001 | Moderately good position, in a garden sloping slightly to N.W. | 77. |
| | 5·02 | 2 „ | 520 | −·003 | | |
| | 5·00 | 4 „ | 1030 | −·003 | | |
| | 4·98 | 5 „ | 1260 | correct. | | |
| | M 5·000 | | | | | |
| 94 | 5·05 | ..... | ..... | ..... | Measuring-glass broken and almost useless. A new one supplied. Gauge in flower-garden, rather too near the house. | 78. |
| | 5·05 | | | | | |
| | 5·05 | | | | | |
| | M 5·050 | | | | | |
| 60 | 7·98 | ·1 | 1320 | −·004 | Observations from this station suppressed, the position being extremely unsuitable, and no improvemet practicable. | 79. |
| | 7·98 | ·2 | 2600 | −·005 | | |
| | 7·98 | ·3 | 6370 | −·003 | | |
| | 8·00 | | | | | |
| | M 7·987 | | | | | |
| 60 | 5·00 | ·1 | 480 | +·004 | See above; gauges Nos. 79 and 80 were close together. | 80. |
| | 5·05 | ·2 | 980 | +·004 | | |
| | 5·02 | ·3 | 1500 | correct. | | |
| | 5·00 | ·5 | 2490 | +·001 | | |
| | M 5·017 | | | | | |
| 50 | 5·05 | ·1 | 498 | +·001 | Very good position, near the crest of the hill; ground undulating. | 81. |
| | 5·04 | ·2 | 980 | +·004 | | |
| | 5·00 | ·3 | 1500 | +·001 | | |
| | 5·02 | ·4 | 2000 | +·001 | | |
| | M 5·027 | ·5 | 2500 | +·001 | | |
| 62 | 4·95 | ·1 | 550 | −·010 | On lawn in a good position, very open to all but N.E., and not much sheltered even from that. | 82. |
| | 5·01 | ·2 | 1030 | −·007 | | |
| | 5·05 | ·3 | 1550 | −·011 | | |
| | 5·03 | ·4 | 2030 | −·008 | [Diameter of funnel increased to 5·12 inches, and gauge thereby rendered almost correct, Oct. 1863.] | |
| | M 5·010 | ·5 | 2570 | −·016 | | |
| 293 | 5·03 | ·1 | 410 | +·019 | Thoroughly exposed, on a large lawn. Had not been in use many months; previous observations cancelled. | 83. |
| | 5·04 | ·2 | 820 | +·038 | | |
| | 5·04 | ·3 | 1120 | +·078 | | |
| | 5·05 | ·5 | 1930 | +·118 | [New glass graduated correctly, supplied Nov. 1863.] | |
| | M 5·040 | 1·0 | 3930 | +·222 | | |
| 140 | 7·95 | ·1 | 1260 | correct. | Position moderately good, on small grass plot in rear of house. | 84. |
| | 8·02 | ·2 | 2510 | +·002 | | |
| | 8·02 | ·3 | 3830 | +·003 | | |
| | 7·97 | ·5 | 6310 | +·002 | | |
| | M 7·990 | | | | | |
| 160 | 7·96 | ·1 | 1260 | correct. | Fixed with the funnel rising 1 ft. above the top of the gable-end of | 85. |
| | 7·96 | ·2 | 2510 | +·001 | | |

EXAMINATION

| Reference number. | Date of examination. | County. | Name of station, owner, and observer. | Construction of gauge. | Maker's name. |
|---|---|---|---|---|---|
| | 1836. | | | | |
| 86. | Sept. 16. | Devon ..... | Exeter, Albert Terrace, R. Dymond, Esq. | III. | ..... 9 |
| 87. | Sept. 16. | Devon ..... | Exeter, High Street, W. H. Ellis, Esq. | VIII. | ..... |
| 88. | Sept. 16. | Devon ..... | Exeter Institution..... | II. | ..... |
| 89. | Sept. 16. | Devon ..... | Exmouth, Bystock, E. Divett, Esq. | III. | Knight & Foster. 9 |
| 90. | Sept. 17. | Devon ..... | Exeter, St. Thomas's Hospital | II. | ..... |
| 91. | Sept. 17. | Devon ..... | Honiton, Broadhembury, Rev. W. Heberden. | III. | ..... |
| 92. | June 8. | Wilts..... | Calne, Castle House, Col. Ward. | III. | Casella ..... 9 |
| 93. | June 8. | Wilts..... | Calne, Castle House, Col. Ward. | III. | Casella ..... 9 |
| 94. | Sept. 26. | Kent ..... | Dover Castle Keep, H. J. Poulter, Esq. | III. | ..... |
| 95. | Sept.. 26 | Kent ..... | Castle Street, Dover, H. J. Poulter, Esq. | III. | ..... |

N-GAUGES (*continued*).

| ight of auge. | | Diameters (that marked M = mean). | Equivalents of water. | | Error at scale-point, specified in previous column. | Remarks on position, &c. | Reference number |
|---|---|---|---|---|---|---|---|
| re ad. | Above sea-level. | | Scale-point. | Grains. | | | |
| in. | feet. | in. | in. | | | | |
| | | 7·97 | ·3 | 3830 | −·004 | the coach house; about 6 ft. of pipe | |
| | | 8·00 | ·5 | 6310 | −·001 | conducts the rain into a bottle placed | |
| | | M 7·972 | | | | in an accessible position. This gauge is 30 ft. from No. 84. | |
| ad | 141 | 5·03 | ·1 | 500 | −·001 | About 200 ft. from No. 84. In a good- | 86. |
| | | 5·02 | ·2 | 990 | +·001 | sized garden, rather sheltered by | |
| | | 4·98 | ·3 | 1460 | +·006 | some peas, which were removed, and | |
| | | 5·00 | ·5 | 2460 | +·005 | a promise was given that nothing | |
| | | M 5·007 | | | | should shelter it again. | |
| 0 | 180 | 9·87 | ·1 | 2050 | −·003 | Rises about a foot above flat roof of | 87. |
| | | 10·12 | ·2 | 4120 | −·007 | observatory; funnel taken down, | |
| | | 9·92 | ·3 | 6200 | −·012 | restored to a truly circular figure, | |
| | | 10·10 | ·5 | 10330 | −·020 | and a correct glass supplied. | |
| | | M 10·003 | | | | | |
| 7 | 155 | ? 6·22 | ..... | ..... | ..... | Gauge so constructed that true dia- | 88. |
| | | ? 6·16 | | | | meters could not be taken; position | |
| | | | | | | very unfavourable; fastened on a | |
| | | | | | | wall, and with a very fine holly tree | |
| | | | | | | 6 ft. above the gauge and not 3 ft. | |
| | | | | | | from it. It was immediately cut | |
| | | | | | | down. | |
| 0 | 340 | 5·12 | ·1 | 520 | −·003 | On a raised part of the roof, near its | 89. |
| | | 4·98 | ·2 | 1000 | +·002 | centre, and perhaps 20 ft. from the | |
| | | 5·14 | ·3 | 1500 | +·003 | nearest side. | |
| | | 4·96 | ·4 | 2020 | +·001 | | |
| | | M 5·050 | ·5 | 2520 | +·002 | | |
| 0 | 50? | ..... | ..... | ..... | ..... | Very old and roughly made, much | 90. |
| | | | | | | sheltered by trees, especially by a | |
| | | | | | | wall-like row of lofty poplars. | |
| 4 | 400 | 4·96 | ·1 | 500 | −·002 | In the hollow stump of a tree, well | 91. |
| | | 4·98 | ·2 | 985 | correct. | exposed in every direction except E., | |
| | | 5·00 | ·3 | 1500 | −·005 | where some laurels were growing | |
| | | 4·97 | ·5 | 2480 | −·005 | too high. Mr. Heberden promised | |
| | | M 4·977 | | | | to have them cut. | |
| 11 | 250 | 5·00 | ·1 | 500 | −·001 | On lawn in an open position; ground | 92. |
| | | 5·00 | ·2 | 1010 | −·004 | level for some distance round the | |
| | | 5·00 | ·3 | 1510 | −·005 | gauge, but it falls to a lower level | |
| | | 5·00 | ·4 | 2010 | −·005 | about 100 yards to the S. | |
| | | M 5·000 | ·5 | 2520 | −·008 | | |
| 0 | 282 | 4·99 | ·1 | 500 | −·001 | On roof, water conveyed by pipe into | 93. |
| | | 5·01 | ·2 | 1100 | −·004 | ground floor; experiments often re- | |
| | | 4·97 | ·3 | 1520 | −·007 | peated show that the loss in passing | |
| | | 5·00 | ·4 | 2020 | −·008 | through this length of pipe is almost | |
| | | M 4·993 | ·5 | 2530 | −·012 | inappreciable. | |
| 0 | 512 | 5·03 | ·1 | 500 | −·001 | By permission of the officer in com- | 94. |
| | | 5·01 | ·2 | 1000 | −·003 | mand of the garrison this gauge was | |
| | | 4·94 | ·3 | 1520 | −·008 | placed on the summit of the keep, | |
| | | 4·97 | ·5 | 2520 | −·011 | the highest point of the Castle, and | |
| | | M 4·988 | | | | regimental orders issued for its | |
| | | | | | | protection by the bombardiers on | |
| | | | | | | duty. | |
| 0 | 16 | 4·78 | ·1 | 500 | −·009 | Funnel made by a local workman as | 95. |
| | | 4·79 | ·2 | 1000 | −·017 | "exactly 5 inches!" A new funnel, | |
| | | 4·79 | ·3 | 1520 | −·030 | 5·03 in. in diameter, was sent to re- | |

EXAMINATION O

| Reference number. | Date of examination. | County. | Name of station, owner, and observer. | Construction of gauge. | Maker's name. |
|---|---|---|---|---|---|
| | 1864. | | | | |
| 96. | Jan. 4. | Surrey ..... | Cobham Lodge, Miss Molesworth. | III. | Knight ..... |
| 97. | Apr. 25. | Leicestershire ... | Thornton Reservoir, Leicester Water-works, Mr. Allen. | IV. | Troughton..... |
| 98. | May 2. | Leicestershire ... | Fleckney, Mr. Putt. ..... | III. | Negretti & Zambra |
| 99. | May 5. | Leicestershire ... | Leicester, Wigston, T. Burgess, Esq. | X. | Negretti & Zambra..... |
| 100. | May 5. | Leicestershire ... | Leicester, H. Billson, Esq. ..... | X. | Negretti & Zambra..... |
| 101. | Sept. 5. | Kent ..... | Margate Royal Sea-Bathing Infirmary, British Association. | III. | Casella ..... |
| 102. | Sept. 10. | Lancashire..... | Royton, Oldham, Mr. Heap. ... | IV. | ..... |
| 103. | Sept. 12. | Lancashire..... | Manchester, Piccadilly, Manchester, Sheffield, and Lincoln Railway Company. | VIII. | Casartelli ..... |
| 104. | Sept. 12. | Lancashire..... | Manchester, Old Trafford, G. V. Vernon, Esq. | X. | Negretti & Zambra..... |
| 105. | Sept. 13. | Lancashire..... | Manchester, Castleton Moor, Rev. J. C. Bates. | III. | Casella ..... |

GAUGE (*continued*).

| ht of ge. Above sea-level. | Diameters (that marked M = mean). | Equivalents of water. Scale-point. | Equivalents of water. Grains. | Error at scale-point, specified in previous column. | Remarks on position, &c. | Reference number. |
|---|---|---|---|---|---|---|
| feet. | in. | in. | | | | |
| | 4·83 | ·5 | 2520 | −·048 | place this one. Position rather sheltered, but the best available. | |
| | M 4·797 | | | | | |
| 100 | 5·00 | ·1 | 500 | −·001 | Fir-tree 30 feet high, 50 feet N. of gauge, and house 40 feet high, 30 feet S. of it, the former having grown since the gauge was placed there. | 96. |
| | 5·02 | ·2 | 1000 | −·001 | | |
| | 5·01 | ·3 | 1500 | −·002 | | |
| | 5·00 | ·4 | 2000 | −·002 | | |
| | M 5·007 | ·5 | 2510 | −·005 | | |
| 374 | 10·15 | ·1 | 2550 | −·025 | Gauge only holds 1·54 inch, a decided fault. Position E. of the reservoir embankment and below it, but so far to the E. that nothing rises 10° above the gauge. In a valley running E. and W. | 97. |
| | 10·16 | ·21 | 4900 | −·031 | | |
| | 10·11 | ·32 | 7250 | −·036 | | |
| | 10·15 | ·40 | 9050 | −·045 | | |
| | M 10·142 | ·50 | 11050 | −·042 | | |
| 452 | 5·02 | ·1 | 450 | +·010 | Hedge 2 feet high, 6 feet S.W.; some trees in W. rise to 32° above gauge. Sunk in garden. Glass wrongly divided, being one division short at the bottom. [Fresh glass supplied.] | 98. |
| | 5·02 | ·2 | 950 | +·010 | | |
| | 5·02 | ·3 | 1480 | +·004 | | |
| | 5·02 | ·4 | 2000 | correct. | | |
| | M 5·020 | ·5 | 2500 | correct. | | |
| 1 210? | 8·00 | ·1 | 1240 | +·002 | Rather surrounded by vegetables; suggested a removal, about 10 feet. | 99. |
| | 8·01 | ·2 | 2475 | +·005 | | |
| | 7·98 | ·3 | 3700 | +·008 | | |
| | 8·00 | ·4 | 4970 | +·008 | | |
| | M 7·997 | ·5 | 6280 | +·005 | | |
| 0 230? | 8·00 | ·1 | 1250 | +·001 | Sheltered, especially in S.W., by trees rising to 50°, in N. to 45°, and in S. to 35°. | 10 |
| | 8·00 | ·2 | 2500 | +·003 | | |
| | 7·99 | ·3 | 3750 | +·004 | | |
| | 8·00 | ·4 | 5050 | +·002 | | |
| | M 7·998 | ·5 | 6280 | +·005 | | |
| 0 25 | 5·00 | ·1 | 496 | correct. | About 100 yards from the sea-shore in garden of principal medical officer; quite exposed. | 101. |
| | 5·00 | ·2 | 1000 | −·002 | | |
| | 5·00 | ·3 | 1490 | −·001 | | |
| | 5·00 | ·4 | 2000 | −·003 | [Reexamined June 2nd, 1866, and found in good order.] | |
| | M 5·000 | ·5 | 2490 | −·002 | | |
| 0 484 | 9·95 | ·05 | 1100 | −·005 | On side of slight valley, sufficiently open. Gauge very rough, the measure being a tin can with a glass slit. [New gauge since supplied, as the correctness indicated by these measurements was believed to be fortuitous.] | 102. |
| | 10·12 | ·10 | 2000 | correct. | | |
| | 10·03 | ·15 | 3000 | correct. | | |
| | 10·11 | ·20 | 3990 | +·001 | | |
| | M 10·052 | ·25 | 4910 | +·005 | | |
| 0 194 | 8·67 | ·1 | 1420 | +·001 | Box fastened to a plank between two ridges of the roof; quite exposed. | 103. |
| | 8·55 | ·2 | 2840 | +·002 | | |
| | 8·26 | ·4 | 5720 | +·002 | | |
| | 8·56 | | | | | |
| | M 8·510 | | | | | |
| 7 106 | 8·03 | ·2 | 2480 | +·004 | In garden at back of Osborne Place, rather sheltered, especially by a tree 20 feet high, 10 feet N.E. of gauge. | 104. |
| | 7·97 | ·4 | 4950 | +·009 | | |
| | 7·99 | | | | | |
| | 7·98 | | | | | |
| | M 7·993 | | | | | |
| 0 475 | 3·00 | ·1 | 170 | +·005 | This and the following gauges, to No. 113 inclusive, are placed in the garden of St. Martin's Vicarage, about ⅛ of a mile S.E. of Blue Pits station. | 105. |
| | 3·01 | ·2 | 340 | +·010 | | |
| | 3·00 | ·3 | 550 | +·007 | | |
| | 3·01 | ·4 | 720 | +·002 | | |

EXAMINATION O

| Reference number. | Date of examination. | County. | Name of station, owner, and observer. | Construction of gauge. | Maker's name. | Time of reading. |
|---|---|---|---|---|---|---|
| | 1864. | | | | | |
| 106. | Sept. 13. | Lancashire..... | Manchester, Castleton Moor, Rev. J. C. Bates. | X. | Casella ..... | 9 a. |
| 107. | Sept. 13. | Lancashire..... | Manchester, Castleton Moor, Rev. J. C. Bates. | VII. | Casella ..... | 9 a. |
| 108. | Sept. 13. | Lancashire..... | Manchester, Castleton Moor, Rev. J. C. Bates. | III. | ..... | 9 a. |
| 109. | Sept. 13. | Lancashire..... | Manchester, Castleton Moor, Rev. J. C. Bates. | III. | ..... | 9 a. |
| 110. | Sept. 13. | Lancashire..... | Manchester Castleton Moor, Rev. J. C. Bates. | XII. | ..... | 9 a.m |
| 111. | Sept. 13. | Lancashire..... | Manchester, Castleton Moor, Rev. J. C. Bates. | X. | Negretti & Zambra | 9 a. |
| 112. | Sept. 13. | Lancashire..... | Manchester, Castleton Moor, Rev. J. C. Bates. | X. | Negretti & Zambra | 9 a. |
| 113. | Sept. 13. | Lancashire..... | Castleton Moor, Rev. J. C. Bates. | X. | Negretti & Zambra | 9 a.m |
| 114. | Sept. 24. | Leicestershire ... | Owston, British Association, Miss Gilford. | III. | Casella ..... | 8 a.m |
| 115. | Nov. 26. | Middlesex ..... | Highgate Nurseries, J. Cutbush, Esq. | III. | Casella ..... | 9 a.m |
| | 1865. | | | | | |
| 116. | Mar. 22. | Kent ..... | Welling, Bexley Heath, H. S. H. Wollaston, Esq. | III. | H. S. H. Wollaston, Esq. | 9 a.m |

-GAUGES (*continued*).

| ht of age. Above sea-level. | Diameters (that marked M=mean.) | Equivalents of water. Scale-point. | Grains. | Error at scale-point, specified in previous column. | Remarks on position, &c. | Reference number. |
|---|---|---|---|---|---|---|
| feet. | in. | in. | | | | |
| | M 3·005 | | | | The situation is quite open, and the gauges are well placed. | |
| 475 | 7·99 | ·1 | 1260 | correct. | | 106. |
| | 7·98 | ·2 | 2540 | −·001 | | |
| | 7·95 | ·3 | 3800 | −·001 | | |
| | 8·00 | ·4 | 5050 | correct. | | |
| | M 7·980 | ·5 | 6300 | +·001 | | |
| 475 | 10·00[a] | ·1 | 2560 | −·001 | | 107. |
| | 10·00 „ | ·2 | 5120 | −·003 | | |
| | 10·00 „ | ·3 | 7630 | −·002 | | |
| | 10·00 „ | ·4 | 10160 | −·002 | | |
| | M 10·000 | ·5 | 12620 | correct. | | |
| 475 | 5·00 | ·1 | 506 | −·002 | | 108. |
| | 5·00 | ·2 | 1020 | −·006 | | |
| | 5·02 | ·3 | 1500 | −·002 | | |
| | 4·98 | ·4 | 2000 | −·003 | | |
| | M 5·000 | ·5 | 2520 | −·008 | | |
| 479 | 5·00 | ·1 | 500 | −·001 | | 109. |
| | 4·98 | ·2 | 980 | +·002 | | |
| | 5·00 | ·3 | 1480 | correct. | | |
| | 4·98 | ·4 | 1975 | correct. | | |
| | M 4·990 | ·5 | 2474 | −·001 | | |
| 494 | 5·00 | ·1 | 506 | −·002 | | 110. |
| | 4·98 | ·2 | 1020 | −·006 | | |
| | 5·00 | ·3 | 1500 | −·003 | | |
| | 5·00 | ·4 | 2000 | −·004 | | |
| | M 4·995 | ·5 | 2520 | −·009 | | |
| 475 | 7·99 | ·1 | 1260 | correct. | | 111. |
| | 7·97 | ·2 | 2510 | +·002 | | |
| | 8·00 | ·3 | 3750 | +·004 | | |
| | 8·00 | ·4 | 5020 | +·004 | | |
| | M 7·990 | ·5 | 6310 | +·002 | | |
| 479 | 7·98 | ·1 | 1260 | +·001 | | 112. |
| | 8·00 | ·2 | 2510 | +·002 | | |
| | 7·98 | ·3 | 3750 | +·004 | | |
| | 8·03 | ·4 | 5020 | +·004 | | |
| | M 7·998 | ·5 | 6310 | +·003 | | |
| 494 | 8·00 | ·1 | 1260 | +·001 | | 113. |
| | 8·02 | ·2 | 2510 | +·002 | | |
| | 7·97 | ·3 | 3750 | +·004 | | |
| | 8·00 | ·4 | 5020 | +·004 | | |
| | M 7·993 | ·5 | 6310 | +·002 | | |
| 580 | 5·00 | ·1 | 500 | −·001 | East end of village, on gentle slope to N. and near the crest of the hill; ground undulates in all directions; gauge well placed. | 114. |
| | 4·99 | ·2 | 990 | correct. | | |
| | 5·00 | ·3 | 1490 | −·001 | | |
| | 5·01 | ·4 | 1980 | +·001 | | |
| | M 5·000 | ·5 | 2480 | correct. | | |
| 394 | 5·00 | ·1 | 500 | − 001 | Houses 20 feet high, 50 feet N. of gauge, all else free. Hill drops rather abruptly to S. | 115. |
| | 5·00 | ·2 | 1000 | −·002 | | |
| | 4·98 | ·3 | 1500 | −·003 | | |
| | 5·02 | ·4 | 2010 | −·005 | | |
| | M 5·000 | ·5 | 2505 | −·005 | | |
| 150 | 5·95 | ·1 | 640 | +·010 | Tree 12 feet high, 8 feet S.E. of gauge, which is 9 inches above roof of green- | 116. |
| | 5·99 | ·3 | 1990 | +·020 | | |

EXAMINATION

| Reference number. | Date of examination. | County. | Name of station, owner, and observer. | Construction of gauge. | Maker's name. | Diam. of |
|---|---|---|---|---|---|---|
| | 1865. | | | | | |
| 117. | Mar. 22. | Surrey ..... | Kew, Kew Committee, B. Baker, Esq. | VII. | ..... | 10 |
| 118. | July 1. | Kent ..... | Acol, Margate, British Association, E. S. Lendon, Esq. | III. | Casella ..... | 9 |
| 119. | July 2. | Kent ..... | Ramsgate, R. Cramp, Esq. ..... | VIII. | Casella ..... | 9 |
| 120. | Sept. 13. | Warwickshire ... | Calthorpe Street, Birmingham, W. Southall, Esq. | X. | Negretti & Zambra | 9 |
| 121. | Sept. 14. | Warwickshire ... | 63 Bloomsbury Street, Birmingham, D. Smith, Esq. | X. | Negretti & Zambra | 9 |
| 122. | Sept. 16. | Bedfordshire ..... | Bedford, Dr. Barker..... | II. | ..... | |
| 123. | Sept. 21. | Derbyshire..... | Chatsworth, Duke of Devonshire, Mr. Taplin. | VIII. | Mr. S. Marshall... | 8 |
| 124. | Sept. 25. | Flintshire ..... | Hawarden, Dr. Moffat..... | X. | Negretti & Zambra | 12 |
| 125. | Sept. 27. | Denbighshire..... | Llandudno, Dr. Nicol ..... | X. | Negretti & Zambra | 9 |
| 126. | Sept. 27. | Carnarvon ..... | Llanfairfechan, R. Luck, Esq.... | III. | Casella ..... | |

N-GAUGES (*continued*).

| ight of auge. | | Diameters (that marked M = mean). | Equivalents of water. | | Error at scale-point, specified in previous column. | Remarks on position, &c. | Reference number. |
|---|---|---|---|---|---|---|---|
| e. d. | Above sea-level. | | Scale-point. | Grains. | | | |
| n. | feet. | in. | in. | | | | |
| | | 5·96 | ·3 | | | house at foot of slope to S. Ground generally level in the neighbourhood. | |
| | | 5·95 | | | | | |
| | | M 5·962 | | | | | |
| 3 | 19 | 10·00 | ·1 | 2570 | −·002 | In Observatory enclosure, but quite freely exposed. Ground level for some distance, especially towards the Thames. | 117. |
| | | 10·00 | ·2 | 5100 | −·002 | | |
| | | 10·01 | | | | | |
| | | 10·00 | | | | | |
| | | M 10·002 | | | | | |
| 0 | 60 | 5·00 | ·1 | 495 | correct. | South end of the village, in a field clear of all obstructions. About 2 miles from sea. Ground gently undulating. | 118. |
| | | 4·99 | ·2 | 990 | correct. | | |
| | | 5·01 | ·3 | 1495 | correct. | | |
| | | 5·00 | ·5 | 2485 | −·001 | | |
| | | M 5·000 | | | | | |
| 6 | 78 | 11·7 | ·1 | 2970 | −·004 | Gauge mounted on top of thermometer stand, in the centre of a kitchen-garden and quite exposed. | 119. |
| | | 12·2 | ·2 | 5850 | −·006 | | |
| | | 12·0 | ·3 | 8670 | −·005 | | |
| | | 12·0 | ·4 | 11700 | −·011 | | |
| | | M 11·975 | ·5 | 14550 | −·011 | | |
| 3 | 510 | 8·00 | ·10 | 1120 | +·012 | Very much sheltered by trees, except to S. and S.W. The observer has always taken 0·10 as 0·09, 0·20 as 0·19, &c., thereby nearly correcting the error. | 120. |
| | | 8·01 | ·21 | 2510 | +·012 | | |
| | | 7·99 | ·05 | 520 | +·009 | | |
| | | 8·00 | | | | | |
| | | M 8·000 | | | | | |
| 10 | 340 | 8·06 | ·11 | 1400 | correct. | Very well placed, in kitchen-garden; quite open. | 121. |
| | | 7·97 | ·20 | 2500 | +·004 | | |
| | | 8·03 | ·40 | 4980 | +·010 | | |
| | | 8·03 | | | | | |
| | | M 8·022 | | | | | |
| 10 | 112 | 12·1 | ..... | ..... | ..... | Internal diameter of cylinder 4·1, and each 0·1 of scale = ·895, therefore gauge very nearly correct; sheltered, however, on all sides by houses and trees. | 122. |
| | | 12·2 | | | | | |
| | | 12·5 | | | | | |
| | | M 12·267 | | | | | |
| 0 | 360? | 8·05 | ·1 | 1240 | +·003 | Gauge on pedestal in kitchen-garden, quite open. | 123. |
| | | 8·00 | ·2 | 2470 | +·006 | | |
| | | 8·03 | ·3 | 3700 | +·010 | | |
| | | 8·00 | ·4 | 4970 | +·010 | | |
| | | M 8·020 | ·5 | 6250 | +·010 | | |
| 5 | 270 | 7·99 | ·1 | 1280 | −·002 | At west end of the village, in large garden; position satisfactory in every respect. | 124. |
| | | 7·96 | ·2 | 2480 | +·003 | | |
| | | 7·94 | | | | | |
| | | 8·00 | | | | | |
| | | M 7·972 | | | | | |
| 9 | 99 | 8·02 | ·40 | 4900 | +·014 | On the eastern slope of Ormes Head, the crest of the hill in N.E. rising 45° above gauge; in other respects well placed. | 125. |
| | | 8·05 | ·15 | 1900 | correct. | | |
| | | 7·90 | ·095 | 1230 | −·002 | | |
| | | 7·96 | | | | | |
| | | 8·07 | | | | | |
| | | M 8·000 | | | | | |
| 8 | 150 | 5·00 | ·1 | 500 | −·001 | Freely exposed on the E. side of a hill, half a mile S.E. of Llanfairfechan railway station. | 126. |
| | | 5·00 | ·2 | 1000 | −·003 | | |
| | | 5·00 | ·3 | 1480 | correct. | | |
| | | 4·95 | ·4 | 1940 | +·006 | | |
| | | M 4·987 | ·5 | 2490 | −·005 | | |

EXAMINATION O

| Reference number. | Date of examination. | County. | Name of station, owner, and observer. | Construction of gauge. | Maker's name. | Time of [illegible] |
|---|---|---|---|---|---|---|
| | 1865. | | | | | |
| 127. | Sept. 27. | Carnarvon ..... | Bangor, Rev. Canon Purvis..... | X. | Negretti & Zambra | 9 a. |
| 128. | Sept. 28. | Carnarvon ..... | Llanberis, Royal Victoria Hotel, Mr. Williams. | III.* | Casella ..... | 9 a. |
| 129. | Sept. 29. | Carnarvon ..... | Beddgelert, Sygun, Mr. Searell. | III.* | Casella ..... | 9 a. |
| 130. | Sept. 30. | Flintshire ..... | Rhyl, Mr. Evans ..... | XII. | Casella ..... | Satu day |
| 131. | Dec. 28. | Surrey ..... | Weybridge, Rev. Dr. Spyer, W. F. Harrison, Esq. | X. | Negretti & Zambra | 9 a.m. on first. |
| 132. | Dec. 28. | Surrey ..... | Weybridge Heath, Bartroppe, W. F. Harrison, Esq. | X. | Negretti & Zambra ..... | |
| | 1866. | | | | | |
| 133. | May 23. | Kent ..... | Nelson Crescent, Ramsgate, Dr. Smiles. | XI. | Negretti & Zambra | 9 a.1 |
| 134. | May 28. | Kent ..... | Canterbury, Chartham, C. T. Drew, Esq. | X. | Negretti & Zambra | 9.3 to pr vious day. |
| 135. | May 28. | Kent ..... | Canterbury Barracks ..... | X. | ..... | ..... |

* These and all other gauges in North Wales, started under the joint auspices of Captain Mathew and Mr. Symons, are made with a cylinder about 5 inches high, rising from the rim,

## GAUGES (*continued*).

| ıt of ge. Above sea-level | Diameters (that marked M = mean). | Equivalents of water. Scale-point. | Equivalents of water. Grains. | Error at scale point, specified in previous column. | Remarks on position, &c. | Reference number. |
|---|---|---|---|---|---|---|
| feet. | in. | in. | | | | |
| 105 | 7·98 | ·1 | 1250 | +·001 | On the N. face of a hill, and near its foot; fair position; mounted on a pillar in the middle of a garden. | 127. |
| | 8·00 | ·2 | 2550 | −·001 | | |
| | 8·00 | ·3 | 3800 | correct. | | |
| | 8·00 | ·4 | 4950 | +·010 | | |
| | M 7·995 | ·5 | 6120 | +·018 | | |
| 370 | 5·00 | ·1 | 500 | −·001 | In the garden of the hotel, a good position, but accessible to tourists; the ratio between these returns and those of the other gauges on the shores of the lake are however very steady. | 128. |
| | 4·99 | ·2 | 990 | correct. | | |
| | 5·01 | ·3 | 1490 | −·001 | | |
| | 5·00 | ·4 | 1980 | +·001 | | |
| | M 5·000 | ·5 | 2480 | correct. | | |
| 330 | 5·00 | ·1 | 500 | −·001 | On a post (otherwise would be sheltered by trees) near the bottom of a gorge, running nearly E. and W. | 129. |
| | 5·01 | ·2 | 1000 | −·002 | | |
| | 4·99 | ·3 | 1480 | +·002 | | |
| | 5·00 | ·4 | 1980 | +·001 | | |
| | M 5·000 | ·5 | 2480 | correct. | | |
| 20 | 5·00 | ..... | ..... | ..... | Gauge placed in a 6-inch iron water-main, in the yard of the gas-works, west end of Rhyl, 100 yards from sea-shore, and nearly level therewith. Glass inaccessible, Mr. Evans being absent. | 130. |
| | 5·00 | | | | | |
| | 4·99 | | | | | |
| | 5·02 | | | | | |
| | M 5·002 | | | | | |
| 53 | 8·00 | ·1 | 1270 | correct. | In kitchen-garden, clear, save that there is a cedar 40 ft. high 60 ft. N.W. of gauge. | 131. |
| | 8·01 | ·2 | 2540 | correct. | | |
| | 8·04 | ·3 | 3800 | +·001 | | |
| | 7·99 | ·4 | 5100 | −·001 | | |
| | M 8·010 | ·5 | 6380 | −·002 | | |
| 150 | 8·00 | ..... | ..... | ..... | In kitchen-garden of Bartropps, on the northern slope of a rising ground ¼ of a mile E.S.E. of Weybridge railway station. Forgot to test glass. Mr. Harrison informed me it agreed with a tested one subsequently sent. | 132. |
| | 8·02 | | | | | |
| | 7·99 | | | | | |
| | 8·01 | | | | | |
| | M 8·005 | | | | | |
| 90 | 5·00 | ·1 | 510 | −·003 | Rather sheltered by trees in N.E. and E., and the house 30 ft. high, 20 ft. S.W. of gauge. Recommended that the gauge be placed on a shelf 8 ft. high, as securing a better position, but still objectionable. | 133. |
| | 5·00 | ·25 | 1240 | correct. | | |
| | 5·00 | ·40 | 1983 | +·001 | | |
| | 5·02 | ·50 | 2459 | +·005 | | |
| | M 5·005 | | | | | |
| 40 | 8·05 | ·01 | 130 | correct. | At the paper mills, in a valley runing about E. and W. Rather sheltered by trees and buildings; moved to a clearer spot. | 134. |
| | 7·95 | ·1 | 1330 | −·005 | | |
| | 7·96 | ·2 | 2550 | −·001 | | |
| | 8·02 | ·4 | 5050 | +·002 | | |
| | M 7·995 | ·5 | 6340 | correct. | | |
| ..... | ..... | ..... | ..... | ..... | Gauge not tested; it is noticed simply to record that at the date stated this gauge was enclosed by a high paling so close round it as to utterly vitiate the returns. | 135. |

whereby snow is more adequately measured. For the comparison of a gauge of this kind, with an ordinary No. III. gauge, see British Rainfall, 1866.

| | | | | | | |
|---|---|---|---|---|---|---|
| [illegible] | May 22. | Kent | ..... | [illegible] W. C. [illegible] | XII. | Candia ..... |
| [illegible] | May 22. | Kent | ..... | [illegible] W. [illegible] Esq. | VII. | Private ..... |
| [illegible] | May 23. | Kent | ..... | [illegible] Esq. | VII. | Horne & Thro[illegible] |
| 139. | May 23. | Kent | ..... | Sheerness Water-works. J. Land, Esq. | XI. | Negretti & Zambra |
| 140. | June 4. | Kent | ..... | Sandwich. Eastry. Walton House. Col. Rae. | XII. | Elliott ..... |
| 141. | June 4. | Kent | ..... | Eastry. The Vicarage, Rev. C. Wilson. | XII. | Elliott ..... |
| 142. | June 5. | Kent | ..... | Hythe, H. B. Mackeson, Esq. | X. | Negretti & Zambra |
| 143. | June 6. | Kent | ..... | Hythe, Saltwood Stone, G. S. Court, Esq. | X. | Negretti & Zambra |
| 144. | June 6. | Kent | ..... | Hythe, Horton Park, J. Kirkpatrick, Esq. | X. | Negretti & Zambra |

## GAUGES (*continued*).

| Height of funnel above ground-level | Diameters that marked (M = mean) | Equivalents of water. Scale-point | Equivalents of water. Grains. | Error at scale-point, specified in previous column. | Remarks on position, &c. | Reference number. |
|---|---|---|---|---|---|---|
| ft. | in. | in. | | | | |
| 140 | 4·96 | ·01 | 50 | correct. | In flower-garden, quite clear except in the W., where there are elms 50 ft. distant and 70 ft. high. | 136. |
| | 5·02 | ·1 | 504 | −·002 | | |
| | 4·99 | ·2 | 1000 | −·002 | | |
| | 5·01 | ·3 | 1490 | −·001 | | |
| | M 4·995 | ·4 | 1980 | correct. | | |
| | | ·5 | 2480 | −·001 | | |
| 169 | 4·00 sq. | ·031 | 100 | +·007 | Gauge on a stump in flower-garden. In the N.W. are trees about 70 ft. distant and 50 ft. high, all else quite open. | 137. |
| | 4·00 | ·063 | 250 | +·002 | | |
| | 4·05 | ·125 | 500 | +·004 | | |
| | 4·10 | ·188 | 720 | +·013 | | |
| | M 4·038 | ·25 | 980 | +·012 | | |
| | | ·50 | 1900 | +·042 | | |
| | | | cub. in. | | | |
| 2 | 5·00 sq. | ·01 | ·22 | +·001 | In flower-garden, fairly open in all directions. | 138. |
| | 5·04 „ | ·1 | 2·5 | +·001 | | |
| | 5·02 „ | ·2 | 5·0 | +·001 | | |
| | 5·00 „ | ·3 | 7·6 | −·002 | | |
| | M 5·015„ | ·4 | 10·2 | −·006 | | |
| | | ·5 | 12·6 | −·001 | | |
| | | | Grains. | | | |
| 9 | 5·00 | ·01 | 50 | correct. | In yard of water-works, slightly sheltered from E. by the tower, otherwise clear. | 139. |
| | 4·99 | ·1 | 500 | −·001 | | |
| | 5·00 | ·2 | 1000 | −·002 | | |
| | 5·01 | ·3 | 1500 | −·003 | | |
| | M 5·000 | ·4 | 1980 | +·001 | | |
| | | ·5 | 2480 | correct. | | |
| 53 | 5·00 | ·01 | 48 | correct. | In open vegetable garden, clear, except in N.E., where there are lofty elms about 90 ft. off. | 140. |
| | 5·02 | ·1 | 500 | −·001 | | |
| | 5·01 | ·2 | 1000 | −·001 | | |
| | 5·00 | ·3 | 1490 | correct. | | |
| | M 5·007 | ·4 | 2000 | −·002 | | |
| | | ·5 | 2500 | −·003 | | |
| 62 | 4·98 | ·1 | 502 | correct. | In centre of large lawn, quite clear, very good position. | 141. |
| | 5·03 | ·2 | 1020 | −·004 | | |
| | 5·05 | ·3 | 1540 | −·007 | | |
| | 5·05 | ·4 | 2000 | +·001 | | |
| | M 5·027 | ·5 | 2500 | +·001 | | |
| 12 | 8·00 | ·1 | 1270 | correct. | First $\frac{1}{100}$th not marked, it was therefore cut on with the writing diamond. In large kitchen-garden, level and quite clear. West end of Hythe. | 142. |
| | 7·96 | ·2 | 2540 | correct. | | |
| | 8·05 | ·3 | 3900 | −·007 | | |
| | 8·00 | ·4 | 5170 | −·007 | | |
| | M 8·002 | ·5 | 6300 | +·004 | | |
| 325 | 8·02 | ·01 | 130 | correct. | On high ground near the railway tunnel; well placed, in kitchen-garden. | 143. |
| | 7·98 | ·1 | 1300 | −·002 | | |
| | 7·98 | ·2 | 2550 | −·001 | | |
| | 8·03 | ·3 | 3900 | −·007 | | |
| | M 8·002 | ·4 | 5100 | −·002 | | |
| | | ·5 | 6300 | −·004 | | |
| 400? | 7·97 | ·1 | 1250 | +·002 | In large flower-pot in centre of lawn. Hills rise somewhat in N. | 144. |
| | 8·04 | ·2 | 2500 | +·003 | | |
| | 8·04 | ·3 | 3700 | +·009 | | |
| | 7·98 | ·4 | 4850 | +·018 | | |
| | M 8·007 | ·5 | 6100 | +·020 | | |

EXAMINATION

| Registration number. | Date of examination. | County. | Name of station, owner, and observer. | Construction of gauge. | Maker's name. | |
|---|---|---|---|---|---|---|
| [illegible] | June [illegible] | Kent | [illegible] Mayfield Hall, R. Appach, Esq. | X. | Negretti & Zambra | [illegible] |
| [illegible] | June 9. | Sussex | Hastings, H[illegible]ington, High Beach, Capt. Lewis. | XII. | Casella | 1[illegible] |
| [illegible] | June 9. | Sussex | Hastings, High Wickham, R. Field, Esq. | XII. | Casella | 9 |
| 148. | June 11. | Sussex | Black Horse, Hastings (new gauge), J. Banks, Esq. | X. | Negretti & Zambra | 8 a. |
| 149. | June 11. | Sussex | Hastings Cemetery, J.C. Savory, Esq. | III. | Private | |
| 150. | June 12. | Sussex | Battle, F. Webster, Esq., Mr. T. Crouse. | III. | Casella | |
| 151. | June 12. | Sussex | Battle, Abbey Gardens, F. Webster, Esq., Mr. Jaques. | III. | Casella | 9 A.I. pre ceding |
| 152. | June 12. | Sussex | Salehurst, Church House, Mr. S. Boorman. | III. | Casella | |
| 153. | June 12. | Sussex | Lamberhurst, Scotney Castle, E. Hussy, Esq. | III. | Knight? | |
| 154. | June 13. | Sussex | Lamberhurst, Court Lodge, W. C. Morland, Esq. | III. | | |

## AUGES (*continued*).

| of above sea-level | Diameters (that marked M = mean). | Equivalents of water. | | Error at scale-point, specified in previous column. | Remarks on position, &c. | Reference number. |
|---|---|---|---|---|---|---|
| | | Scale-point. | Grains. | | | |
| feet. | in. | in. | | | | |
| 171 | 7·97 | ·1 | 1270 | correct. | In kitchen-garden; fair exposure. | 145. |
| | 8·00 | ·2 | 2550 | −·001 | | |
| | 8·00 | ·3 | 3800 | correct. | | |
| | 8·01 | ·4 | 5100 | −·002 | | |
| | M 7·995 | ·5 | 6360 | −·002 | | |
| 286 | 5·00 | ·01 | 50 | correct. | On terraced walk, on a hill facing W., perfectly open in every direction. | 146. |
| | 4·99 | ·1 | 500 | −·001 | | |
| | 5·01 | ·2 | 1000 | −·002 | | |
| | 4·99 | ·3 | 1500 | −·003 | | |
| | M 4·992 | ·4 | 1980 | correct. | | |
| | | ·5 | 2480 | −·001 | | |
| 212 | 5·00 | ·1 | 510 | −·003 | Open in all directions except S.W., where the house, 30 ft. high, is only about 30 feet off. | 147. |
| | 5·00 | ·2 | 1000 | −·002 | | |
| | 5·00 | ·3 | 1500 | −·003 | | |
| | 5·00 | ·4 | 2020 | −·008 | | |
| | M 5·000 | ·5 | 2500 | −·004 | | |
| 20 | 8·00 | ·05 | 640 | −·001 | House 20 ft. high, 10 ft. distant in E., all else clear. [Close to gauge No. 54; both are regularly observed, the readings are "generally nearly alike, if anything No. 148 is in excess," which is exactly what the testing shows.] | 148. |
| | 7·98 | ·1 | 1320 | −·004 | | |
| | 7·97 | ·2 | 2550 | −·001 | | |
| | 8·00 | ·3 | 3900 | −·008 | | |
| | M 7·988 | ·4 | 5080 | −·001 | | |
| | | ·5 | 6350 | −·002 | | |
| 500 | 5·02 | ..... | ..... | ..... | In the middle of the cemetery; high ground and very open; measured occasionally, but no glass there on that date. | 149. |
| | 5·04 | | | | | |
| | 4·96 | | | | | |
| | 5·08 | | | | | |
| | M 5·003 | | | | | |
| ..... | 4·98 | ·01 | 50 | correct. | In a garden, the house 25 ft. high, being 40 ft. N. of the gauge, otherwise clear. | 150. |
| | 5·00 | ·1 | 510 | −·003 | | |
| | 4·97 | ·2 | 1030 | −·008 | | |
| | 5·02 | ·3 | 1530 | −·009 | | |
| | M 4·993 | ·4 | 2030 | −·010 | | |
| | | ·5 | 2530 | −·012 | | |
| ..... | 4·93 | ·1 | 510 | −·03 | Slightly sheltered from S.E., but on the whole in a good position. | 151. |
| | 5·04 | ·2 | 1010 | −·004 | | |
| | 5·00 | ·3 | 1510 | −·005 | | |
| | 5·03 | ·4 | 2020 | −·008 | | |
| | M 5·000 | ·5 | 2500 | −·004 | | |
| ..... | 5·00 | ·1 | 510 | −·003 | On a post in garden; rather sheltered in W. by a tree 30 ft. high, 30 ft. off, and in S.W. by others 20 ft. high and 20 ft. off. | 152. |
| | 5·02 | ·2 | 1010 | −·003 | | |
| | 5·02 | ·3 | 1520 | −·006 | | |
| | 4·98 | ·4 | 2030 | −·009 | | |
| | M 5·005 | ·5 | 2500 | −·003 | | |
| 241 | 5·03 | ·1 | 540 | −·007 | At angle of the castle terrace, quite open. | 153. |
| | 5·05 | ·2 | 1050 | −·008 | | |
| | 5·08 | ·3 | 1550 | −·007 | | |
| | 5·02 | ·4 | 2010 | +·002 | | |
| | M 5·045 | ·5 | 2560 | −·007 | | |
| 190 | 5·04 | ·1 | 550 | −·009 | Not in operation, but to be started January 1st, 1867. | 154. |
| | 5·08 | ·2 | 1050 | −·007 | | |
| | 5·03 | ·3 | 1530 | −·002 | | |
| | 5·08 | ·4 | 2030 | correct. | | |
| | M 5·057 | ·5 | 2550 | −·003 | | |

| Registered number. | Date of examination. | County. | Name of station, owner, and observer. | Class and number of glass. | Maker's name | Time of |
|---|---|---|---|---|---|---|
| | 1366. | | | | | |
| 155. | June 13. | Kent | Goudhurst, Mr. Stevens | XII. | Casella | |
| 156. | June 13. | Kent | Cranbrook, Hartley, G. Filmer, jun. Esq. | XII. | Casella | |
| 157. | June 14. | Kent | Cranbrook, Tilden, Mr. T. Filmer | II. | Mason | |
| 158. | June 14. | Kent | East Sutton Park, Sir K. Filmer, Mr. Sumner. | X. | Negretti & Zambra | 9 a |
| 159. | June 14. | Kent | Linton Park, J. Robson, Esq. | X. | Negretti & Zambra | 9 a |
| 160. | June 16. | Kent | Hunton Court, W. Bannerman, Esq. | X. | Negretti & Zambra | |
| 161. | June 16. | Kent | East Peckham, Orchard Cottage, S. T. Harris, Esq. | XI. | Negretti & Zambra | 9 a.r |
| 162. | June 15. | Kent | Tunbridge, Dr. Fielding | III. | Bates | 9 a |
| 163. | | Kent | Maidstone, Fant Road, J. H. Baverstock, Esq. | V. | Casella | mont ly. |
| 164. | June 16. | Kent | Maidstone, Soverfield, F. Dobell, Esq. | II. | Annan of Heddes-don. | mont ly. |
| 165. | June 16. | Kent | Aylesford, Capt. Cheere | XII. | Casella | |
| 166. | June 16. | Kent | Maidstone, Larkfield, Rev. W. Dinock. | III. | Casella | |

| of / ove ra- el. | Diameters (that marked M = mean). | Equivalent of water. Scale-point. | Grains. | Error at scale-point, specified in previous column. | Remarks on position, &c. | Reference number. |
|---|---|---|---|---|---|---|
| et. | in. | in. | | | | |
| 375 | 5·00 | ·1 | 500 | −·001 | Slightly sheltered, but probably not injuriously; in N.E., however, the house is only 30 ft. off, and perhaps 30 ft. high. | 155. |
| | 5·00 | ·2 | 990 | correct. | | |
| | 5·00 | ·3 | 1490 | −·001 | | |
| | M 5·000 | ·4 | 1980 | +·001 | | |
| | | ·5 | 2480 | correct. | | |
| 350 | 5·01 | ·1 | 500 | −·001 | Mounted on a brick column in the middle of a field, very carefully placed. | 156. |
| | 4·98 | ·2 | 1000 | −·002 | | |
| | 5·00 | ·3 | 1490 | −·001 | | |
| | 5·01 | ·4 | 2000 | −·003 | | |
| | M 5·000 | ·5 | 2500 | −·004 | | |
| ..... | ..... | ·08 | 500 | ..... | In a valley, and too much sheltered by trees; there is an apple-tree 35 ft. high only 25 ft. to E., and a fig-tree 10 ft. high 8 ft. to S. | 157. |
| | | ·16 | 1000 | | | |
| | | ·24 | 1500 | | | |
| | | ·32 | 2000 | | | |
| | | ·39 | 2500 | | | |
| 387 | 7·99 | ·01 | 140 | −·001 | Found some currant bushes very near. They have since been moved. | 158. |
| | 8·05 | ·1 | 1300 | −·002 | | |
| | 8·04 | ·2 | 2570 | −·002 | | |
| | 7·97 | ·4 | 5110 | −·001 | | |
| | M 8·013 | ·5 | 6380 | −·001 | | |
| 296 | 7·96 | ·1 | 1250 | +·001 | In kitchen-garden, quite open. | 159. |
| | 7·98 | ·2 | 2600 | −·006 | | |
| | 7·99 | ·3 | 3890 | −·008 | | |
| | 8·00 | ·4 | 5240 | −·014 | | |
| | M 7·983 | ·5 | 6500 | −·014 | | |
| 80 | 8·00 | ·1 | 1290 | −·002 | In kitchen-garden, somewhat sheltered by shrubs in N.E. Close to ornamental lake. | 160. |
| | 8·01 | ·2 | 2580 | −·003 | | |
| | 7·99 | ·3 | 3840 | −·002 | | |
| | 8·00 | ·4 | 5100 | −·002 | | |
| | M 8·000 | ·5 | 6340 | +·001 | | |
| 76 | 5·00 | ·1 | 500 | −·001 | On the grass margin of a large tank provided for water-fowl; clear, and in a level tract of country. | 161. |
| | 5·00 | ·2 | 1000 | −·002 | | |
| | 5·00 | ·3 | 1500 | −·003 | | |
| | 5·00 | ·4 | 2000 | −·003 | | |
| | M 5·000 | ·5 | 2500 | −·004 | | |
| 71 | 5·00 | ·1 | 500 | −·001 | In flower-garden, clear, except a tree 10 ft. high 40 ft. S.S.W. of gauge. | 162. |
| | 4·98 | ·2 | 1000 | −·002 | | |
| | 5·00 | ·3 | 1500 | −·003 | | |
| | 4·99 | ·4 | 2000 | −·004 | | |
| | M 4·993 | ·5 | 2500 | −·006 | | |
| ..... | 4·98 | ·01 | 50 | correct. | Houses 40 ft. high about 30 ft. off, in E.S.E. and N; all else clear. | 163. |
| | 4·98 | ·1 | 500 | −·002 | | |
| | 4·97 | ·2 | 1010 | −·006 | | |
| | 4·96 | ·3 | 1500 | −·006 | | |
| | M 4·973 | ·4 | 2000 | −·008 | | |
| | | ·5 | 2500 | −·010 | | |
| ..... | 20·25 | ..... | ..... | ..... | Diameter of tube 10¾ inches, and scale 4 inches = inch, therefore reads correctly. Quite open, in kitchen-garden. | 164. |
| | 20·50 | | | | | |
| | 20·75 | | | | | |
| | M 2·050 | | | | | |
| ..... | 4·98 | ·1 | 500 | −·001 | On lawn, sloping to river. Araucaria 8 ft. high, 10 ft. W. | 165. |
| | 5·01 | ·2 | 1000 | −·002 | | |
| | 4·99 | ·3 | 1490 | −·001 | | |
| | 5·00 | ·4 | 1980 | correct. | | |
| | M 4·995 | ·5 | 2480 | −·001 | | |
| ..... | 5·00 | ·01 | 50 | correct. | Found in rather a sheltered position; suggested removal, which was adopted. | 166. |
| | 4·99 | ·10 | 500 | −·001 | | |
| | 5·02 | ·20 | 990 | −·001 | | |
| | 5·00 | ·30 | 1490 | correct. | | |
| | M 5·003 | ·40 | 1980 | +·001 | | |
| | | ·50 | 2480 | correct. | | |

*Report on the best means of providing for a Uniformity of Weights and Measures, with reference to the Interests of Science. By a Committee, consisting of* Sir JOHN BOWRING, The Rt. Hon. C. B. ADDERLEY, *M.P.*, Sir WILLIAM ARMSTRONG, *C.B.*, *F.R.S.*, The ASTRONOMER ROYAL, SAMUEL BROWN, W. EWART, *M.P.*, Dr. FARR, F. P. FELLOWS, Prof. FRANKLAND, Prof. HENNESSY, *F.R.S.*, JAMES HEYWOOD, *M.A.*, *F.R.S.*, Sir ROBERT KANE, *F.R.S.*, Dr. LEONE LEVI, *F.S.A.*, Prof. W. A. MILLER, *F.R.S.*, Prof. RANKINE, *F.R.S.*, C. W. SIEMENS, *F.R.S.*, Col. SYKES, *M.P.*, *F.R.S.*, W. TITE, *M.P.*, *F.R.S.*, Prof. A. W. WILLIAMSON, *F.R.S.*, Lord WROTTESLEY, *D.C.L.*, *F.R.S.*, JAMES YATES, *F.R.S.*

YOUR Committee have much pleasure in reporting that during the year steps of great importance have been taken to promote the adoption of one common decimal system of weights and measures, both at home and abroad. In November 1865 a second Conference was held at Frankfort, of official delegates from different German States, including Austria, Prussia, Bavaria, Saxony, Hanover, Wurtemberg, Baden, Hesse, Mecklenburg, Nassau, Oldenburg, and the Hanse Towns, with a view of determining the basis of a uniform system for the whole of Germany, in confirmation of what had been agreed upon in 1863, on which occasion, however, Prussia was not represented. By a protocol of the 28th of November, the delegates resolved to take the metre as a unit of measure with the other portions of the metric system, allowing the coexistence of the foot of 3 decimetres, the inch of 3 centimetres, and the line of 3 millimetres. It is much to be regretted that by thus combining two otherwise antagonistic systems, the Commissioners have thrown an impediment to the absolute introduction of the metric system; but the question will doubtless be subject to further consideration. The war which has taken place in Germany has delayed the consideration of this and other measures of progress; but it is gratifying to learn that one of the first conditions laid down in the preliminaries of peace was the establishment of a uniform system of weights and measures, not only over the north for Germany under the immediate influence of Prussia, but over the southern portions also.

In the United States of America considerable advance has also been made. Seizing the opportunity of Mr. Yates Thompson's visit to the States, your Committee desired him to ascertain what steps were taken on the subject in that country; and it is gratifying to learn that the Americans seem prepared to advance further and much more expeditiously than we have done. Mr. Thompson, whose able Report we have the pleasure to append (p. 355–363), informed us that on the recommendation of a Select Committee on weights, measures, and coinage, appointed by the National Academy of Science, two Bills were introduced in the Senate and House of Representatives, one rendering the use of the metric system lawful in the United States, and the other authorizing the use in Post-offices of weights of the denomination of grammes; whilst joint resolutions were passed, enabling the Secretary of the Treasury to furnish to each State one set of the standard weights and measures of the metric system, and authorizing the President to appoint a Special Commissioner to facilitate the adoption of one uniform coinage between the United States and foreign countries. These resolutions passed the House of Representatives with little or no opposition. The two Bills have passed into law.

The approaching Universal Exhibition in Paris in 1867 appeared to your

Committee a most favourable opportunity for promoting uniformity in weights and measures, and they have suggested to the Imperial Commission an Exhibition of the weights, measures, and coins of all countries, and the holding of an International Conference on the subject at the same time. A similar request was sent to the Imperial Commission by the International Decimal Association, and in union with them we deputed Professor Leone Levi to proceed to Paris to put himself in communication with M. Le Play, the Commissaire-General, with a view to the advancement of the object. Professor Levi has fully succeeded in his mission, and a Special Committee of the Scientific Commission has been appointed. Your Committee indulge the hope that the proposed Exhibition with the International Conference will greatly promote the desired uniformity, and they are most anxious for the success of an undertaking in initiating which they have taken an active part. Professor Levi's report on the subject is appended (pp. 363–365).

The International Statistical Congress, which met last at Berlin in 1863, proposes to hold its next Meeting in Florence in October next. At all its previous meetings the question of uniformity of weights, measures, and coins, in their character as statistical units, formed the subject of grave discussion; and although the Congress has not only repeatedly expressed its opinion in favour of uniformity, but made specific recommendations with a view to its attainment, it is most desirable that it should on this occasion also, when many of the Southern States of Europe are likely to be there represented, give its authoritative voice in favour of uniformity in weights, measures, and coins, both for statistical purposes, and the general progress of scientific and social intercourse among nations. The British Association has never yet been represented in that Congress, and it seems befitting that the section of Statistics and Economic Science should seize the opportunity for the discussion of a subject in which both that Congress and this Association have taken such lively interest, and for the establishment of a correspondence and mutual representation likely to prove most beneficial to Statistical Science; and Italy, whose contributions to science and art and political economy have been so valuable, will doubtless heartily welcome the representatives of this great and eminently progressive Association.

The state of weights and measures in India has been brought before your Committee in two pamphlets, one on Indian weights and measures, by Mr. Gover, Principal of the Military Male Orphan Asylum of Madras, and the other by Mr. James Bridgnell, Head Accountant of Her Majesty's Mint, Calcutta, entitled, "Suggestions for a Decimal System of Measures, Weights, and Money for India." Having regard to the great importance of extending to that empire the same advantages of uniformity as we are labouring to promote in other parts of the world, your Committee have sent an address on the subject to the government of India. The question is now under their consideration; but much difference of opinion exists between the Madras and Bombay Commissions on the respective merits of the decimal and binary systems. It is most important that India should neither be separated from nor remain behind any country in the world; and we trust that at the forthcoming Exhibition and International Conference to be held in Paris she will send copies of all her weights, measures, and coins, and be duly represented in the French capital, especially as her trade with countries using the metric system is becoming more and more extensive.

It is much to be desired that a measure for legalizing the use of metric weights and measures, similar to that passed in the United Kingdom, should be introduced in all the British Colonies, and your Committee would be glad

to obtain the cooperation of Her Majesty's Secretary for the Colonies in so important a matter.

At home, the only legislative measure recently passed bearing on the subject, is one for transferring to the Board of Trade the department of weights and measures, previously connected with the office of the Comptroller of the Exchequer. Your Committee regret that no provision has been made in the Act for authorizing that Board to provide themselves with a copy of the standard metric weights and measures, with a view to the stamping of the metric weights and measures in common use. The law on the subject *is in* a very anomalous state. Although the Metric Weights and Measures Act of 1864 has rendered permissive and legal the use of such weights and measures, the inspectors of weights and measures are by law bound to seize any such weights and measures not duly stamped; and since no means are now afforded for stamping them, the Act is rendered inoperative. Seeing that the system is being extensively introduced in many arts and manufactures, and in commerce generally, it is much to be desired that the law on the subject may speedily be amended. A deputation from your Committee waited on the late President of the Board of Trade, Mr. Milner Gibson, on the subject, and he promised to consider the introduction of a separate measure to remove the anomaly. But the session was too far advanced, and nothing has been done.

Among the means by which Her Majesty's Government could promote such introduction, we might mention the preparation of all statistical documents by the Board of Trade in the terms of the metric system as well as in the imperial, and the publication of the British Tariff in a similar manner. The International Statistical Congress has strongly urged the former of these measures, and we see no reason why the Board of Trade and the Board of Customs should not supply these additional facilities, both to statists and British merchants. Although the articles now subject to Customs duty are very few, still the operation of the British Tariff is most perplexing to those accustomed only to a decimal computation.

Your Committee have given their earnest consideration to the procuring of a Mural Standard as a means for diffusing information; and they have appointed a Subcommittee to ascertain and report on the best form and material in which such standard can be constructed. The Subcommittee have devoted much time to the subject, and they have finally succeeded in obtaining from Mr. Casella a model of a Metre and Yard combined, which seems to fulfil all the conditions necessary for the proper exhibition of these measures in the most conspicuous places. A special report on the subject by the convener of the Subcommittee, Mr. James Yates, is appended (pp. 365–367). The Committee propose purchasing some copies of such standard; and as the cost is five guineas each, the sum already voted by the Association will be barely sufficient for this item alone.

Your Committee are anxious to see school instruction made more operative towards extending the knowledge of the metric system among the young. To promote this object, they have addressed themselves to the President of the Committee of Council on Education, for the purpose of suggesting the introduction of the metric system into the examination of teachers in the training schools supported by parliamentary grant, and a conference with teachers and others interested in education was held on the subject at the Lecture Theatre in Jermyn Street. Great difficulty is, however, experienced in inducing teachers to give due prominence to the metric system, so long as the use of it is only permissive, and all the tables of weights and measures according to the imperial system are still to be taught.

The measures and weights of the metric system having been almost universally adopted by scientific chemists, there seemed to be every reason to expect that they would be adopted in pharmacy also. This has been done in some countries which have not yet introduced the system into commerce. The Swedish Pharmacopœia is constructed on this principle, and in the United States of America prescriptions are written in terms of the metric system. In this country the change has hitherto been opposed by the General Council of Medical Education and Registration, which issues its decrees under the authority of an Act of Parliament. In these circumstances, the Metric Committee of the British Association resolved to address the Medical Council, suggesting that "the objection formerly urged to the introduction of the metric system side by side with the imperial in all the formulas for the preparation of drugs and chemicals, that the metric weights and measures were not yet sanctioned by the Legislature, is now removed by the passing of the Metric Weights and Measures Act," and expressing the desire of the Metric Committee that the system may be introduced into the forthcoming new edition of the Pharmacopœia. Hereupon the following resolution was passed: "That the General Medical Council are not prepared to adopt, in its full extent, the suggestion of the Metric Committee of the British Association; but the Council will direct that a complete comparative table of metric and imperial weights and measures, with instructions for their mutual conversion, shall be inserted in the forthcoming edition of the British Pharmacopœia."

Your Committee thought it probable that great advantages would arise from the introduction of the metric system in the carrying department of railways. On this question Professor Levi consulted some of the officials at the Clearing-house in London, and Mr. Louis d'Eyncourt, a member of the Council of the International Decimal Association, embraced the opportunity of a visit to Boulogne to make inquiries regarding the goods traffic by railway between England and France. But although the evidence thus obtained was important and decisive, it appeared that the Royal Commission on the Railways in Great Britain and Ireland was not disposed to proceed with the inquiry.

Your Committee have reason to believe that they have already exercised considerable influence in the promotion of an object of so wide and general importance as the uniformity of weights, measures, and coins in all countries; and, in conclusion, they would recommend the reappointment of the Committee with similar powers, and another vote of at least fifty pounds towards the purchase of copies of the Mural Standard, and more especially in connexion with the forthcoming Universal Exhibition and International Statistical Congress.

*Report on the Progress of the Metric System in the United States of America.* *By* H. YATES THOMPSON, *F.S.S.*

GENTLEMEN,—In accordance with your letter to me, dated 17th February 1866, I took occasion, on a visit to the United States of America in May and June last, to ascertain what steps are being taken by friends of the Metric System of Weights and Measures to promote its adoption in that country.

It appears that ever since the settlement of the Constitution in 1789, wherein it was declared that Congress should have power "to fix the standard of weights and measures," there has been a continual effort, which has hitherto been without practical result, to obtain a uniform and decimal

system of weights and measures for the United States. In 1790, in accordance with a recommendation of President Washington, Mr. Jefferson, the Secretary of State, reported elaborately on the subject; and it is probable that one or other of the plans proposed by him would have been carried into effect, had not the proposals of the French Government for an international system inclined the American Legislature to wait and watch the result of the efforts made in France before initiating any radical changes in their own weights and measures. The adoption of the metric system in America does not seem to have been urged till very recently. During the early part of the century that system was still an experiment in France, and by adopting it the Americans would have sacrificed, what was then more important to them than now, uniformity with England. But its inherent merits were so great, and its ultimate success was becoming so probable, that, although Mr. Jefferson in 1790 recommended the seconds pendulum as the standard of measure, Mr. John Quincy Adams, to whom the matter was referred by the Senate in 1817, and who reported in 1821 in probably the most exhaustive essay that has been written on the subject, advised a suspension of all innovation at home until an international scheme could be adopted by America in conjunction with foreign nations. Though Mr. Adams did not recommend in so many words the adoption of the metric system, there is no doubt that that was the system which he most admired. Indeed, in one remarkable passage, he almost puts off the gravity of the statesman to anticipate with rapturous enthusiasm the time when "the metre will surround the globe in use as well as in multiplied extension, and one language of weights and measures will be spoken from the equator to the poles."

The plan which he did recommend consisted of two parts, the principles of which were—

1. To fix the standard with the partial uniformity of which it is susceptible, for the present excluding all innovation.
2. To consult with foreign nations for the future and ultimate establishment of universal and permanent uniformity.

The first part of Mr. Adams's plan has been in a great degree accomplished. I visited at Washington the building in which are deposited the standards of the weights and measures of the United States, under the charge of J. E. Hilgard, who is now Acting Suprintendent of Weights and Measures in place of Professor Bache. From this central office of Weights and Measures, full sets of standards, including most beautiful and accurate balances, have been furnished to all the States and Custom-houses of the country. Each State Government in its turn directs the distribution of standards to its counties; and in States where the further subdivision of towns exists, as, for example, in the State of New York, the authorities of each county are instructed by a law of the States to provide each town with standard weights, measures, and balances, and to compare them with the county standard once in every five years.

The office of Weights and Measures at Washington contains, moreover, several copies of the metric standards which have been from time to time furnished by the French Government. The first of these were sent to Congress in 1795, being copies of the provisional metre and kilogram. The latest addition was made in 1852, and consists of three different series:—

1. A standard metre of steel upon a bronze base and a standard kilogram of brass gilt.
2. A graduated brass metre and a litre, both by Gambey.

A complete and valuable collection of the whole apparatus composing

in France the assortment of a bureau of verification of weights and measures of the first order.

It will be seen, therefore, that the American Government has not only brought its present system for the manufacture and distribution of its own standards to a considerable degree of perfection, but is already amply provided with copies of the metric standards.

With regard, however, to the second of Mr. Adams's suggestions, viz. "to consult with foreign nations for the future and ultimate establishment of universal and permanent uniformity," no progress has yet been made. The subject has been commended to Congress on two occasions by Secretaries of the Treasury; in 1847 by the Hon. R. J. Walker, and in 1861 by Mr. Chase, who is now Chief Justice of the Supreme Court of the United States. Scientific men generally throughout the country had been for some time gradually coming to the conclusion that the metric system was that which ought to be adopted; but it was not till the International Congresses, postal and statistical, held at Paris and Berlin in 1863, that the idea took a practical form. The United States was represented at the Paris Postal Congress by the Hon. J. A. Kasson, and at the Statistical Congress in Berlin by the Hon. S. B. Ruggles. Both these gentlemen were deeply impressed with the advantages of the metric system. They participated in the strong resolutions adopted at both these Congresses in favour of its general adoption; and in December 1863 Mr. Ruggles forwarded to the Secretary of State a Report on the subject, which was printed as a public document, and contained in an appendix (A) the Report of the Special Commission appointed by the Statistical Congress of 1860 on International Weights, Measures, and Coins; (B) a copy of the Debate in the House of Commons on the Metric Bill of 1863. This document was republished by the State Government of New York at Albany in 1864, and was in such request that a further issue was required in 1865. At the same time, the Legislature of the State of Connecticut (it is to be remembered that only State Governments in America have to do with education) had recommended to all its school officers that the metric system be taught in the schools of the State.

We must bear in mind that during the above period, from 1863 to 1865, the civil war was raging, and it is therefore not surprising that the leading American statesmen had little time to give to such matters as weights and measures. Mr. Chase, however, had (in 1863) procured the appointment, by the National Academy of Sciences, of a Committee on Weights, Measures, and Coinage. This National Academy of Sciences had been incorporated in 1863 by the Senate and House of Representatives of the United States, and consists of a body of not more than fifty scientific men, whose chief duty it is, whenever called upon by any department of the Government, to "investigate, examine, experiment, and report upon any subject of science or art." This Committee included all the most notable men of science in America who had given special attention to weights and measures. The members were as follows:—Joseph Henry, *Chairman*; J. H. Alexander, Fairman Rogers, Wolcott Gibbs, Arnold Guyot, Benjamin Silliman, Jun., William Chauvenet, John Torrey, A. D. Bache, John Rodgers, L. M. Rutherfurd, Professor Newton, Samuel B. Ruggles, J. E. Hilgard.

After a thorough investigation of the subject in January 1866, these gentlemen reported shortly in favour of the authorization and encouragement by Congress of the introduction and use of the metric system; and with a view to this it made three practical suggestions:

1. The immediate manufacture and distribution to the Custom-houses and States of metric standards of weights and measures.

2. The introduction of the system into the Post-offices, by making a single letter weigh 15 grammes, instead of 14·17 grammes or half an ounce.

3. To cause the new cent and two-cent pieces to be so coined that they shall weigh respectively 5 and 10 grammes, and that their diameter shall be made to bear a determinate and simple ratio to the metric unit of length.

Such were the recommendations which the National Academy of Sciences forwarded to Congress in January last. The Report was at once referred to a Standing Committee of the House of Representatives on Weights, Measures, and Coins, which had been wisely constituted at the beginning of the present Congress to take cognizance of this important subject. This Committee was constituted chiefly through the exertions of the Hon. J. A. Kasson, who became its Chairman, and to his energy its prompt action is greatly due. He obtained the assistance of Professor Newton, of Yale College, a well-known man of science, as Clerk to the Committee; and with his aid a Report was prepared and printed in May last, which is well worthy of the attention of all friends of the metric system.

After examining at some length the whole subject of weights and measures in the United States, Mr. Kasson's Report proceeds to demonstrate the progress which is being made by the metric system throughout the world. With regard to the action of England, it declares that the course taken by the House of Commons "must be regarded as evincing a deliberate intention to introduce the metric system into England, and as giving up any purpose of creating a separate system founded upon the yard, the foot, or the inch, and as paving the way for the ultimate exclusive adoption of the metric system."

The Report next points out and illustrates by Tables the inconveniences and want of system of the weights and measures now in use in America, with all which we are sufficiently acquainted, and contrasts therewith the order, simplicity, and perfect harmony of the metric plan.

The Report pronounces strongly on several grounds against a change of nomenclature, and after illustrating by a Table the somewhat astonishing fact that of the total value of the imports and exports of the United States for 1860, which amounted in all to 762,000,000 dollars, the amount of nearly 700,000,000 dollars was with nations and their dependencies that have now authorized or taken the preliminary steps to authorize the metric system, concludes as follows:—

Your Committee unanimously recommend the passage of the Bills and joint Resolutions appended to this Report. They were not prepared to go, at this time, beyond this stage of progress in the proposed reform. The metric system is already used in some arts and trades in this country, and is especially adapted to the wants of others. Some of its measures are already manufactured at Bangor, in Maine, to meet an existing demand at home and abroad. The manufacturers of the well-known Fairbanks scales state, "For many years we have had a large export demand for our scales with French weights, and the demand and sale is constantly increasing." Its minute and exact divisions specially adapt it to the use of chemists, apothecaries, the finer operations of the artisan, and to all scientific objects. It has always been and is now used in the United States' coast survey*. Yet in some of the States, owing to the phraseology of their laws, it would be a direct violation of them to use it in the business transactions of the community. It is therefore very important to legalize its use, and give to the people, or that portion of them desiring it, the opportunity for its legal employment, while the knowledge of its characteristics will be thus diffused among men.

* I ascertained that the metric weights are in use in the Assaying Department of the U.S. Treasury at New York, and by analytical chemists generally throughout America.—I. Y. T.

Chambers of commerce, boards of trade, manufacturing associations, and other voluntary societies and individuals will be induced to consider and in their discretion to adopt its use. The interests of trade among a people so quick as ours to receive and adopt a useful novelty will soon acquaint practical men with its convenience. When this is attained (a period, it is hoped, not distant), a further Act of Congress can fix the date for its exclusive adoption as a legal system. At an earlier period it may be safely introduced into all public offices and for Government service.

In the schedule of equivalents provided in the Bill, extreme scientific accuracy is not expressed. The reasons follow. The exact length of the meter in inches and the weight of the kilogram in grains can of necessity be determined only approximately. The most careful determinations of these quantities now possible are liable to minute corrections hereafter as more numerous observations are made and better instruments are used. Instead, therefore, of aiming at an accuracy greater, perhaps, than is attainable, it is more expedient to consult the convenience of the people by using the simplest numbers possible in the schedule, and yet such as shall be in fact more nearly exact than can ever be demanded in the ordinary business of life. These numbers are to be used in schools and in practical life millions of times as multipliers and divisors, and every unnecessary additional figure is justly objectionable.

In a popular sense of the word, however, the numbers in the schedule may be said to be exact. The length of the meter, for example, is given as 39·37 inches. The mean of the best English and the best American determinations differs from this only by about the amount by which the standard bar changes its length by a change of one degree of temperature. Such accuracy is certainly sufficient for legal purposes and for popular use.

The second measure recommended is a joint resolution, necessarily following the adoption of the leading Bill, and provides for furnishing the standards, which will thereby be required, to the several States.

The third proposition is a Bill to authorize and provide for the use of the weight of 15 grams in the Post-office, in conformity with the system adopted by that department for foreign correspondence.

The fourth is a Resolution looking to effective negotiation for a uniform coinage among nations.

Respectfully submitted,

JOHN A. KASSON, *Chairman.*
CHARLES H. WINFIELD.
THOMAS WILLIAMS.
HEZEKIAH S. BUNDY.
HENRY L. DAWES.

## BILLS AND RESOLUTIONS ACCOMPANYING THE REPORT.

### *A Bill to authorize the use of the Metric System of Weights and Measures.*

*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,* That from and after the passage of this Act, it shall be lawful throughout the United States of America to employ the weights and measures of the metric system; and no contract, or dealing, or pleading in any court, shall be deemed invalid, or liable to objection, because the weights or measures expressed or referred to therein are weights or measures of the metric system.

SEC. 2. *And be it further enacted,* That the tables in the schedule hereto annexed shall be recognized, in the construction of contracts, and in all legal proceedings, as establishing in the terms of the weights and measures now in use in the United States, the equivalents of weights and measures expressed therein in terms of the metric system; and said tables may be lawfully used for computing, determining, and expressing in customary weights and measures the weights and measures of the metric system.

*Measures of Length.*

| Metric Denominations and Values. | | Equivalents in Denominations in use. |
|---|---|---|
| Myriameter .. | 10,000 meters. | 6·2137 miles. |
| Kilometer .... | 1,000 meters. | 0·62137 mile, or 3280 feet 10 inches. |
| Hectometer .. | 100 meters. | 328 feet 1 inch. |
| Dekameter .. | 10 meters. | 393·7 inches. |
| Meter ..... | 1 meter. | 39·37 inches. |
| Decimeter .... | $\frac{1}{10}$th of a meter. | 3·937 inches. |
| Centimeter .. | $\frac{1}{100}$th of a meter. | 0·3937 inch. |
| Millimeter .. | $\frac{1}{1000}$th of a meter. | 0·0394 inch. |

*Measures of Surface.*

| Metric Denominations and Values. | | Equivalents in Denominations in use. |
|---|---|---|
| Hectare..... | 10,000 square meters. | 2·471 acres. |
| Are ..... | 100 square meters. | 119·6 square yards. |
| Centare..... | 1 square meter. | 1·550 square inch. |

*Measures of Capacity.*

| Metric Denominations and Values. | | | Equivalents in Denominations in use. | |
|---|---|---|---|---|
| Names | No. of liters. | Cubic measure. | Dry measure. | Liquid or wine measure. |
| Kiloliter or stere | 1000 | 1 cubic meter .... | 1·308 cubic yard .. | 26·417 gallons. |
| Hectoliter..... | 100 | $\frac{1}{10}$ of a cubic meter. | 2 bus. and 3·35 pecks | 26·417 gallons. |
| Dekaliter ..... | 10 | 10 cubic decimeters | 9·08 quarts..... | 2·6417 gallons. |
| Liter..... | 1 | 1 cubic decimeter.. | 0·908 quart..... | 1·0567 quart. |
| Deciliter ..... | $\frac{1}{10}$ | $\frac{1}{10}$ of cubic decimeter | 6·1022 cubic inches | 0·845 gill. |
| Centiliter ..... | $\frac{1}{100}$ | 10 cubic centimeters | 0·6102 cubic inch .. | 0·338 fluid-ounce. |
| Milliliter ..... | $\frac{1}{1000}$ | 1 cubic centimeter .. | 0·061 cubic inch .. | 0·27 fluid-drachm. |

*Weights.*

| Metric Denominations and Values. | | | Equivalents in Denominations in use. |
|---|---|---|---|
| Names. | Number of grams. | Weight of what quantity of water at maximum density. | Avoirdupois weight. |
| Millier or tonneau . | 1,000,000 | 1 cubic meter ..... | 2204·6 pounds. |
| Quintal..... | 100,000 | 1 hectoliter ..... | 220·46 pounds. |
| Myriagram ..... | 10,000 | 10 liters..... | 22·046 pounds. |
| Kilogram or Kilo.. | 1,000 | 1 liter ..... | 2·2046 pounds. |
| Hectogram ..... | 100 | 1 deciliter..... | 3·5274 ounces. |
| Dekagram..... | 10 | 10 cubic centimeters .. | 0·3527 ounce. |
| Gram..... | 1 | 1 cubic centimeter .... | 15·432 grains. |
| Decigram ..... | $\frac{1}{10}$ | $\frac{1}{10}$ of a cubic centimeter | 1·5432 grain. |
| Centigram..... | $\frac{1}{100}$ | 10 cubic millimeters .. | 0·1543 grain. |
| Milligram ..... | $\frac{1}{1000}$ | 1 cubic millimeter .... | 0·0154 grain. |

*Joint Resolution to enable the Secretary of the Treasury to furnish to each State one set of the Standard Weights and Measures of the Metric System.*

*Be it resolved by the Senate and House of Representatives of the United States of America in Congress assembled,* That the Secretary of the Treasury be, and he is hereby, authorized and directed to furnish to each State to be delivered to the Governor thereof, one set of the standard weights and measures of the metric system, for the use of the States respectively.

*A Bill to authorize the use in Post-offices of Weights of the denomination of Grams.*

*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,* That the Postmaster-General be, and he is hereby, authorized and directed to furnish to the Post-offices exchanging mails with foreign countries, and to such other offices as he shall think expedient, postal balances denominated in grams of the metric system; and, until otherwise provided by law, one half ounce avoirdupois shall be deemed and taken for postal purposes as the equivalent of fifteen grams of the metric weights, and so adopted in progression; and the rates of postage shall be applied accordingly.

*Joint Resolution to authorize the President to appoint a Special Commissioner to facilitate the adoption of an Uniform Coinage between the United States and Foreign Countries.*

*Be it resolved by the Senate and House of Representatives of the United States of America in Congress assembled,* That the President be, and he is hereby, authorized to appoint a Special Commissioner to negotiate with foreign Governments for the establishment of the common unit of money, of identical value in all commercial countries adopting the same; that all Governments with which the United States hold diplomatic relations be invited to participate in the negotiations. That any plan which may be agreed upon by part of or all the representatives engaging in such negotiations be submitted to Congress for its approval before being carried into effect in the United States; and that the compensation allowed to such Commissioner be the amount necessary for his actual and proper expenses incurred in the execution of his duties.

The above Bills and Resolutions passed the House of Representatives with little or no opposition. They are now before the Senate, which has referred them to a Committee, of which the Hon. Charles Sumner is Chairman; and his well-known and enlightened views on the subject encourage the hope that, either in this session or next, the Senate will confirm the action of the House of Representatives*.

Such is the present position of the metric movement in the United States.

I may add that the general public in America seems inclined to receive the new system favourably. Several of the leading newspapers have noticed it in terms of welcome and commendation; and it is notorious that the knowledge which all Americans possess of the great advantages of a decimal system of coinage, render them likely to appreciate all the more fully the merits of the metric system of weights and measures.

Nor are its promoters careless of advantages likely to result from the spread of instruction on the details of the system in schools. I have already mentioned its adoption as a part of education in the schools of Connecticut. I was assured that it only needs that the permissive Bill be passed, for many other States to follow the example of Connecticut.

In February last a large number of Professors, Presidents of Colleges, and

* Since this Report was put in type, news has arrived that Mr. Sumner's Committee, on the 16th of July, reported favourably the above Bills and Resolutions, all without amendment; and still more recently we have been informed that the two Bills have passed into law.

others connected with education in the United States, issued an address to editors and publishers of Arithmetics, urging—

1. That to the Arithmetics now published an appendix be at once added, that shall contain a full explanation of the *metric system of weights and measures*, and of their relation to the weights and measures now in common use, and that the whole be illustrated by suitable and numerous examples.

2. That in every revised edition of Arithmetics now used, and in every *new* Arithmetic, a proper development of this system have a place in the body of the work; and that in examples for practice occurring thereafter, there be frequent reference to these weights and measures.

I learned that Messrs. Stoddard and Co., of New York, were in June last already engaged in introducing an explanation of the metric system into revised editions of Stoddard's Arithmetics—an important series; and I further ascertained that the authors and publishers of at least three other series of Arithmetics have promised similar introduction.

I left with Professor Henry, Secretary of the Smithsonian Institution at Washington, a copy of Dowling's Synoptic Table, which will be exhibited in the Museum of the Institution; and I doubt not that we shall soon hear of similar Tables or charts of the metric system being made in America for the use of schools. I have much pleasure in acknowledging Professor Henry's courtesy in suggesting that any parcels which we wish to send to our friends in America, may be sent free of expense through the Smithsonian Institution. We shall certainly do well to supply them with copies of any mural standards, school metres, or other appliances which may be devised for extending the knowledge of the metric system. In the Report of the Smithsonian Institution for this year, which will shortly appear, and which is very widely circulated, will be found Tables of equivalents of the metric and English systems of weights and measures, compiled by Professor Newton.

The first two pages of Mr. Kasson's Report are devoted to the question of Coinage. Upon this subject the Committee makes no recommendation of a specific nature beyond the joint resolution quoted above. It is therefore singular that the first actual step in advance towards a practical adoption of the metric system in the United States has been made through the Mint in the following manner.

In May last an Act was passed through the House of Representatives, on the motion of the Hon. J. A. Kasson, and through the Senate, on the motion of the Hon. John Sherman, which subsequently was signed by the President and became law, authorizing the coinage of five-cent pieces of copper and nickel in place of the paper five-cent currency then in circulation, and fixing their weight at 77·16 grains, equiponderant to 5 grams of the metric system. The diameter of this coin was fixed at 20 millimetres, and they have already been issued from the Mint in large quantities, so that every citizen of the United States now carries in his pocket a weight and measure of the metric system. When the Bill authorizing the issue of this coin passed through Congress, the Chamber of Commerce of New York at once held a meeting to express its satisfaction, and unanimously voted thanks to Messrs. Kasson and Sherman for their exertions in thus teaching the people by actual experience the uses and value of the metric system.

No better instance could be given than the above of the practical and energetic manner in which the friends of the metric system in America are taking up the subject. It is greatly to be hoped that our present Parliament will not slacken its efforts in the direction in which the last Parliament made so good a beginning. I may mention, however, that our friends in America

find it difficult to understand how it has happened that, after the unanimous Report of the Committee of the House of Commons in 1862, in favour of the ultimate adoption of the Metric System of Weights and Measures, nothing has yet been done by our Government to make our people acquainted with the details of that system by the distribution of Standards, and its introduction as a branch of education into schools aided by public money.

I am, Gentlemen, with much respect,
Your obedient Servant,
H. YATES THOMPSON.

2 Cleveland Row, St. James's, London, S.W.
July 27th, 1866.

*Report on the Exhibition of Weights, Measures, and Coins at the Universal Exhibition in Paris*, 1867. *By* Professor LEONE LEVI, *F.S.A.*, *F.S.S.*

GENTLEMEN,—In compliance with the desire of the Metric Committee of the British Association and the Council of the International Decimal Association, I proceeded to Paris to confer with M. Le Play, the Commissaire-General of the Universal Exhibition for 1867, with regard to the proposed special exhibition of the Measures, Weights, and Coins of all countries; and I have the pleasure to report that the utmost desire was shown to forward the object in view, the same being quite in consonance with the design of that Great Exhibition.

Already had the Imperial Commission anticipated to some extent our suggestions, since by decree of the 20th September 1865, an International Scientific Commission was constituted for the purpose of assisting in propagating useful discoveries and promoting reforms of an international interest, such as the adoption of the same weights and measures, of common scientific units, &c., Mr. James Yates, F.R.S., Vice-President of the International Association, having been nominated one of its members.

In order to elicit an expression of opinion on the subject, and at the same time to secure the concurrence of the Commissioners of different countries at the time in Paris, M. Le Play summoned a preparatory Conference on the subject, which was held at the Palais de l'Industrie on the 2nd of May, when the proposal of holding such an Exhibition was fully considered and approved. On my arrival in Paris, another meeting was held of the same Conference, and both were attended by persons of great distinction belonging to France and other countries. In the observations which I had the honour of making, I showed the progress already made towards the uniformity of weights, measures, and coins in different countries, as well as what remains yet to be done, and I concluded by suggesting—

First, a special Exhibition of Weights, Measures, and Coins of all countries;

Secondly, the collection of all official documents and reports bearing on the question of uniformity;

And, thirdly, the holding an International Conference at the time of such an Exhibition to consider the weights, measures, and coins exhibited by all countries, and the documents referring to the same, and to prepare a report on the best means of attaining the desired uniformity as speedily as possible.

M. Le Play, representing the Imperial Commissioners, gave his complete sanction to the proposal; and he suggested that a small Committee from the Scientific Commission should be appointed by the President of the Imperial Commission to promote the object, the same to be afterwards enlarged by

the addition of foreign members to be nominated by the Exhibition Commissioners in different countries, each nation contributing to bear a proportional share of any expense, which, however, could not be great.

In accordance, therefore, with the suggestion promulgated by the Metric Committee and the International Association, and with the resolutions adopted by the Conferences held at the Palais de l'Industrie, an ordinance on the subject was issued by the President of the Imperial Commission on the 2nd of June last, which appropriated a space in the Palace for the exhibition of measures, weights, and coins of all countries, and appointed a Special Committee from the Scientific Commission to preside over this particular Exhibition.

The Committee thus formed, of which I have the honour of being a member, held its first meeting during my stay in Paris, when, after organizing ourselves by nominating our senior member, M. Mathieu, of the Bureau des Longitudes, President, and Messrs. Baudrillart and Becquerel, Secretaries, we prepared a circular to be sent to the Commissioners appointed *in all* countries for the Universal Exhibition, communicating to them a copy of the ordinance of the Minister of State and the minutes of the Conferences held in the Palais de l'Industrie, and inviting their cooperation on the subject. An important step has thus been taken which will, I trust, greatly stimulate the object we have at heart, viz. the adoption of the same system of measures, weights, and coins in all countries.

Permit me now to add that, having regard to the part taken by the Metric Committee of the British Association and the International Decimal Association in suggesting such an Exhibition, it is much to be desired that we should do our utmost in assisting the International Committee in the attainment of the object. The Royal Commissioners for the Exhibition of 1867, of which His Royal Highness the Prince of Wales is Chairman, *will* be invited to send to that Exhibition a copy of all the weights and measures legal in this country, and two collections of the current coins of the realm. I trust the Metric Committee of the British Association and the Council of the International Association will commend the subject to the attention of the British Commission, and so secure their compliance with the request.

In the name of the International Decimal Association, I have promised that the collection of weights and measures made for the International Exhibition of 1862, and deposited in the Kensington Museum, shall be placed at the disposal of the International Committee for the purpose, and upon this also it will be necessary to communicate with the authorities of the Kensington Museum.

Still more important, however, is the nomination of delegates to take part in the great Conference which will be held at the time of the Exhibition. This Conference should consist of men able to study the objects and documents there exhibited from a scientific and practical point of view; and it is most important that the two scientific Associations, to whom I have the honour to address myself, should communicate with Her Majesty's Government, soliciting them to appoint official representatives to the same Conference from the Mint and the Board of Trade, and that you should also write to the Chambers of Commerce in the United Kingdom, showing the practical advantage of their responding in due time to the invitation of the International Committee by appointing delegates to the same Conference. The Council of the International Decimal Association may also appeal to its Vice-Presidents in all countries, soliciting their good offices with their respective Governments, with a view to secure their cooperation in pro-

noting the proposed Exhibition, and appointing official delegates to the Conference.

My best thanks are due to M. Le Play for his kindness towards me during my visit to Paris, and I should fail in my duty were I not to acknowledge with gratitude the care and interest shown by M. De Chancourtois in the promotion of the object of my mission to that great metropolis.

I have the honour to be, Gentlemen,

Your obedient Servant,

LEONE LEVI.

Farrar's Building, Temple,
July 1866.

*Report on the Mural Standard.* *By* JAMES YATES, *F.R.S.*

I TAKE up the account of the Mural Standard, exhibiting in immediate opposition the Yard and the Metre with their divisions, where I laid it down last year at Birmingham*.

The want of Mural Standards of the linear measures has been shown on the authority,—

1st, of the Commissioners for the restoration of the Standards, whose Report, with the evidence, was published by order of Parliament in 1841 (see pp. 16, 17);

2ndly, of G. B. Airy, Astronomer-Royal, in his letter to Lord Monteagle, Comptroller of the Exchequer, dated Feb. 1st, 1859;

3dly, of Lord Monteagle himself, in his letter transmitting that of Professor Airy to the Secretary of State for the Home Department (see Appendix to the Report quoted below);

4thly, of the Select Committee of the House of Commons on Weights and Measures, A.D. 1862 (see their Report, p. ix).

These Commissioners and public officers all concur in advising that Mural Standards of length should be exhibited in public places, where they may be accessible to the people generally. But, although this subject has been earnestly and repeatedly recommended to the attention of the Government, and although the advice so given is agreeable to the general practice of civilized nations both in Europe and America, yet nothing has been done by our Government to give effect to these recommendations.

Parliament has, however, passed a law, which received the Royal Assent on the 6th instant, and which may be regarded as a first step. The Select Committee of the House of Commons, to which I have alluded, adopted (A.D. 1862) a series of Recommendations, one of which was, "that a Department of Weights and Measures be established in connexion with the Board of Trade." This has been done by the Standards of Weights, Measures, and Coinage Act, 1866, Sections 1, 10, 11, 12. But much remains to be done, and Mr. Ewart, the Chairman of the before-mentioned Select Committee, has accordingly given notice of a motion next Session to reappoint the Committee with a view to facilitate the introduction into this country of the Metric System of Weights and Measures. The task imposed on the Committee will be no less arduous than that which they executed with such distinguished success in the spring of 1862. It will be the duty of those who are friendly to this great improvement to avail themselves of the interval by collecting all kinds of evidence, which may guide the Committee in their determinations; and we trust that they will continue to act in

* See Report of the Birmingham Meeting (Sections), p. 159.

the same liberal and enlightened spirit, and in conjunction with the many able and excellent men, in both Houses of Parliament, whether in or out of office, who now combine their efforts in the same direction. The extensive exhibition and use of our Mural Standard will, as we may confidently anticipate, be among the principal means of accomplishing the object.

The Committee of the British Association, soon after its appointment, thought it desirable to appply for advice and assistance to the Chemical Society, which includes many of the most eminent chemists and metallurgists in the kingdom. Their application was granted in the kindest manner by the President of the Society, Dr. William Allen Miller, the Secretary, Dr. Odling, and the other members of the Council. The subject was brought before the Society at two of its meetings, and the result was a very important change in the course of proceeding. Professor Frankland advised that, instead of Baily's metal, or any other metallic substance, either simple or compound, the Mural Standard should be made of white glazed porcelain. The question was carefully considered, more especially in regard to the durability of porcelain, and its susceptibility of changes by expansion and contraction. With regard to durability, we know from innumerable examples that porcelain will last for hundreds of years without any perceptible decay. We also know that it is very little subject to expansion and contraction from the changes of atmospheric temperature. But it is also well known that all objects made of clay contract by exposure to great heat. How could we pass our porcelain Standard through the ordeal of a furnace without destroying the dimensions marked upon it? In this difficulty we were fortunate in obtaining the assistance of Mr. Casella, Philosophical Instrument Maker to the Board of Ordnance. This gentleman, whose business makes him familiar with works of this particular description, instituted a series of experiments, which proved that a slab of porcelain after completion contracts visibly on its reexposure to a great heat, but that, if the heat be sufficiently intense and sufficiently long continued, an adequate security will be obtained against future change. Consequently a slab may be prepared by firing at first, and then have the lines etched in with hydrofluoric acid, the figures and letters painted with enamel, the lines rubbed in with the same, and then the lines, figures, and letters all burnt in, after which treatment it will not shrink at all. Having obtained so satisfactory a result, the Committee desired Mr. Casella to proceed with his work.

The Committee have seen no reason to make any important change in the form and dimensions of the instrument. These remain nearly as they were shown to the Statistical Section of the British Association at Birmingham. But, as the Yard was then placed in close contact with the Metre, a question arose whether the two measures might not be more clearly distinguished from each other; and to effect this it was proposed that the Yard should be marked in red lines and the Metre in blue. This suggestion was adopted, and the instrument, thus completed, is thought to be elegant and attractive as well as clear and distinct. If, however, any persons prefer having it marked with black lines this may be done.

It was requisite that the divisions should be so exact that no inaccuracy could be perceived either by the sight or the touch. This has been accomplished by our artist, who obtained from M. Perreaux, of Paris, one of his beautiful dividing instruments, which is so constructed as to divide, if required, to the 500th part of a millimetre, a length far more diminutive than can ever be found necessary. About the tenth of a millimetre is sufficient to answer every useful purpose.

Besides showing the name of the maker on each instrument as a voucher for its accuracy, the Committee hope to obtain the stamp of the Government as directed by Act of Parliament. But as the stamp could not be impressed on the porcelain, a number will be marked and burnt on every instrument, and the same number with the Government stamp will be impressed on the frame.

The price cannot be at present determined. We can only say that it will not exceed £5 5*s*. When the demand is sufficient the price may be lowered.

Whilst Mr. Casella has been employed upon our Mural Standard, a Birmingham artist, Mr. Gargory, who pursues the same line of business, has produced an instrument which may be called a School Metre, being especially adapted for school use. It is made of wood and ivory. It shows the Metre together with the Yard, both Long and Cloth Measure, the principles of its construction being generally the same with those of the Mural Standard. Its price will be about 7*s*.

The sum of £50 voted by the British Association at Birmingham having been expended, it will be necessary to ask for a further grant. If the General Committee of the Association should think it proper to send copies of the Mural Standard to all the places where the Association has met, or even to a considerable number of them, a grant of £100 will not be too much; and it may be deserving of consideration, that if philosophers, who are proverbially poor, can afford such a sum as £100, the Lords of Her Majesty's Treasury, who have hitherto expended nothing on this great and indispensable public provision, need not grudge any amount which may be found requisite.

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*An Account of Meteorological and Physical Observations in Three Balloon Ascents made in the years* 1865 *and* 1866 (*in continuation of twenty-five made in the years* 1862, 1863, *and* 1864), *under the auspices of the Committee of the British Association for the Advancement of Science, by* JAMES GLAISHER, *F.R.S., at the request of the Committee, consisting of* Colonel SYKES, The ASTRONOMER ROYAL, Lord WROTTESLEY, Sir D. BREWSTER, Sir J. HERSCHEL, *Bart.*, Dr. LLOYD, Dr. ROBINSON, Mr. GLAISHER, Mr. GASSIOT, Prof. TYNDALL, Dr. FAIRBAIRN, *and* Dr. W. A. MILLER.

AT the first appointment of the Balloon Committee it was charged with the determination of the law of the decrease of temperature with increase of elevation, as the primary object of research; and some two years since this law seemed to have been pretty well determined, but up to that time the experiments had been, for the most part, made in the months of summer and during the hours of afternoon. The principal duty of the Committee was the verification of the results then found, by including experiments at other times of the day, and at other seasons of the year. It was expected that this part of the work to be done by the balloon would have been completed. In carrying out these experiments, it was found that those taken in the morning hours did not accord with those taken in the afternoon hours, nor did those taken at one time of the year agree with those taken at other times of the year. In the course of these experiments an accidental descent just at

the time of sunset showed very little or no difference of temperature for a height of nearly half a mile. The question then arose as to whether it was possible that at night the temperature might increase with elevation, and not decrease as always heretofore had been considered, and acted upon whenever such entered into physical investigation.

The Committee last year therefore was reappointed with special reference to night observations at any time of the year made within a moderate distance of the earth. To make day observations, in winter and the adjacent months at any hour in the day; in summer to be made in the morning, only the subject of temperature to be considered as of the first importance, with any other of the usual experiments which might be possible. Up to the Meeting at Birmingham twenty-five ascents had been made, of which seventeen had been made in the months of June, July, August, and September, but not one in May, and mostly during the hours of afternoon.

### § 1. Instruments and Apparatus.

The instruments were of the same construction as those used in the previous experiments; in addition well-made miners' lamps were used to illuminate the instruments at night.

### § 2. Observing Arrangements.

The instruments were in all cases placed on suitable framework, attached to the outside of the car, and sufficiently protected from all effects of radiation.

### *Circumstances of the Ascents, and General Observations.*

*Ascent from Woolwich Arsenal, October 2*, 1865.—The first ascent after the Meeting at Birmingham was made on October 2nd. The balloon used was that of Mr. Orton, of Blackwall.

When the sun had set for nearly three-quarters of an hour and night had fairly set in, the moon shining brightly, and the sky free from cloud, the balloon left Woolwich Arsenal at $6^h\ 20^m$, the temperature at the time being 56°. Within three or four minutes a height of 900 feet was reached, and till this time I failed in directing the light of the Davy lamp properly. When I succeeded the temperature was 57° and increasing; on reaching 1200 feet high it had increased to 58°·9; we then descended to 900 feet, and the temperature decreased to 57°·8; on turning to ascend again the temperature increased to 59°·6 at 1900 feet high, being 3½° warmer than when the earth was left. On descending again the temperature decreased to 57½° at the height of 600 feet, and in the several subsequent ascensions and descensions the temperature increased with elevation, and decreased on approaching the earth. On every occasion the highest temperature was met with at the highest point. This result was remarkable indeed. The different degrees of the humidity of the air met with in this ascent are no less remarkable. Considering saturated air as represented by 100, at the commencement of the ascent in the balloon it was 95; at Greenwich Observatory it was 84; towards the end of the ascent in the balloon it was 85, and at Greenwich was 97. The state of things was reversed, and would indicate that the water in the air had fallen. Its amount at the beginning of the ascent was 5¼ grains in a cubic foot of air, and at the same elevation was 4½ grains in the same mass of air at the end of the ascent.

The readings of the instruments were taken very slowly, owing to the difficulty experienced in directing the light properly. I failed in all magnetic experiments, and indeed in nearly all but those relating to temperature and

humidity. Two self-registering minimum thermometers were tied down, one with its bulb resting on cotton-wool, fully exposed to the sky, and the other with its bulb projecting beyond the supporting frame; their indexes were at the end of their columns of spirit on starting, or at 56°. At every examination of each of these instruments a space was found between its index (which remained unmoved) and the end of the column of spirit, indicating a temperature higher than before leaving, and it was closely approximate at all times to the temperature of the air. Consequently, notwithstanding the clearness of the sky, the loss of heat by radiation must have been small. No ozone was shown at the Royal Observatory, but in the balloon paper tests were coloured to 4, on a scale of greatest intensity being considered 10.

At the early part of this ascent I was wholly occupied with the instruments, and when at the height of about 1000 feet, the view which suddenly opened far exceeds description. Almost immediately under, but a little to the south-east, was Woolwich; north was Blackwall; south, Greenwich and Deptford; and west, as far as the eye could reach, was London—the whole forming a starry spectacle of such brilliancy as far to exceed anything I ever saw. When I have been at this elevation in the evening, at a distance from London, it has had the appearance of a vast conflagration, but on this night the air was so clear and free from haze that each and every light was distinct, and apparently all but touching each other.

The whole of Woolwich, Blackwall, Deptford, and Greenwich could be traced as a perfect model by the line of lights of their streets and squares. In nine minutes we were opposite Brunswick Pier, Blackwall, crossing the Thames, then passed across the Isle of Dogs, Greenwich Reach, and so up the River Thames. As we advanced towards London, the mass of illumination increased in intensity. At $6^h\ 42^m$ the South-Eastern Railway Terminus at London Bridge was directly under us; looking southward at this time we saw the Borough stretching far away, and the many streets shooting from it, particularly Southwark Street, with its graceful curve of lamps. In one minute more we were over Southwark Bridge, 1300 feet high, passed Blackfriars Bridge at $6^h\ 45^m$, and Charing Cross at $6^h\ 47^m$.

On leaving Charing Cross I looked back over London, the model of which could be seen and traced—its squares by their lights, the river, which looked dark and dull, by the double row of curved lights on every bridge spanning it. Looking round, two of the illuminated dials of Westminster clock were like two dull moons. Again, looking eastward, the whole lines of Commercial and Whitechapel Roads, with their continuations through Holborn to Oxford Street, were visible, and most brilliant and remarkable. We were at such a distance from Commercial Road that it appeared like a line of brilliant fire, assuming a more imposing appearance when the line separated into two, and most imposing just under in Oxford Street. Here the two thickly studded rows of brilliant lights were seen on either side of the street, with a narrow dark space between, but which dark space was bounded, as it were, on both sides by a bright fringe like frosted silver. At first I could not account for this appearance; but presently, at one point more brilliant than the rest, persons were seen passing, their shadows being thrown on the pavement, and at once it was evident this rich effect was caused by the bright illumination of the shop lights on the pavements.

I feel it impossible to convey any adequate idea of the brilliant effect of London, viewed at an elevation of 1300 feet, on a clear night, when the air is free from mist.

It seemed to me to realize a wish I have felt when looking through a telescope at portions of the Milky Way, when the field of view appeared covered with gold-dust, to be possessed of the power to see those minute spots of light as brilliant stars, for certainly the intense brilliancy of London this night must have rivalled such a view.

We were over the Marble Arch at $6^h\ 51^m$, about eleven miles in a straight line from Woolwich, which distance had been passed in about half an hour. We therefore were travelling at more than twenty miles per hour. On passing onwards we left the Edgeware Road on our right, and the Great Western Railway on our left, and passed nearly down the Harrow Road. In six or seven minutes we left the suburbs of London, passing over Middlesex in the direction of Uxbridge; there the contrast was great indeed; not a single object could anywhere be seen, not a sound reached the ear; the roar of London was entirely lost. The moon was shining, but seemed to give no light; and the earth could not be seen. After a time the moon seemed to shine with increased brightness; the fields gradually came into view, then the shadow of the balloon on the earth was seen distinctly pointing out our path, which, by reference to the pole-star and the moon, became well known. After this occasional masses of lights appeared as we passed over towns and villages. Thus we passed out of Middlesex, over parts of Buckinghamshire and Berkshire, to Highmoor, in Oxfordshire, where we descended on the farm of Mr. Reeves at $8^h\ 20^m$, distant about 45 miles from Woolwich. The horizontal movement of the air at Greenwich in the same time was registered as 16 miles.

Unfortunately, Mr. Orton believed we were near the sea, and, notwithstanding my assertions and assurances to the contrary, he suddenly brought the balloon to the ground, and broke nearly all the instruments; the lamp was lost, but an offered reward brought it to me a fortnight afterwards in a very battered condition.

The results of this first night experiment are very valuable; and, so far as one experiment can give, indicate that, on a clear night, the temperature, up to a certain elevation, increases with increase of elevation.

*Ascent from Woolwich Arsenal, December* 2, 1865.—The weather during the month of November was too boisterous to attempt an ascent at night, and no opportunity presented itself till December 2. This day was cloudless, and held out the prospect of a clear sky at night.

The balloon was filled, and it was ready before sunset; for some time after this it continued clear, but suddenly became overcast, obscuring the moon. When the sun had set nearly $2\frac{1}{2}$ hours, we left Woolwich, Mr. Orton taking charge of the balloon. The temperature of the air just before leaving was $38\frac{1}{2}°$, at 1400 feet high it decreased 2°: unlike the previous ascent, the lowest temperature was always at the highest point, and the highest was at the lowest point of every ascent and descent, of which there were several instances at the highest point reached; when nearly one mile high the temperature was 27°, being 11° colder than when we left the earth, one hour and a half before; we then descended with the view of ascending again still higher, when unfortunately, at the height of 2400 feet, the lamp was thrown down by a jerk of the balloon, and went out; just before this the temperature was $32\frac{1}{2}°$. On losing the light we continued the descent to the earth.

Pilot balloons started shortly before leaving, having indicated the lower current of air as S.E., and the upper nearly W. On leaving Woolwich we passed over Stratford, Tottenham, St. Albans, towards Tring; when here we considered ourselves high enough to venture out of the lower current, and on

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doing so, at the height of 3000 feet, we changed our direction, and moved with some W. in the wind; on descending again to the same level we fell in with the S.E. current.

During the whole ascent the sky was covered with cloud, and we neither saw the moon, nor could distinguish her place in the heavens, and we had to depend on the compass entirely for a knowledge of the course we were taking. This we could readily do; for although the sky was uniformly covered with cloud, with very many detached clouds below us, some of which were very near the earth, yet when no cloud was directly under us, the boundary of every field was clearly visible, even at the height of one mile. By carefully noting the angle and direction our course made with edges of the field, we determined the direction we were moving. Thus guided we kept in the lower current till we passed so far inland as to be safe from the sea, towards which the upper current would have taken us. The results of this night's experiments differ from those taken on October 2, by showing a small decrease of temperature with increasing elevation. They were made, however, entirely under the cloud; for at our highest point the cloud was uniformly dense, and situated far above us.

In our course we passed a little north of London, but, owing to a cloud of less elevation than 1000 feet between us and London, we did not see a single light, or anything of London, forming a great contrast to the experience of the previous ascent.

Arrangements were made for ascents at night in January and February, and for several months the balloon was kindly stored at night at Woolwich for the use of the Committee; but my health failed, and for many months I was too unwell to attempt an ascent at night, and thus passed till April.

*Ascent from Windsor, May* 29, 1866.—I have already said that no ascents had been made in May; Mr. Westcar, of the Royal Horse Guards, then stationed at Windsor, kindly offered the use of his balloon, and arrangements were made at different times in May, but, as is usual, some fruitless attempts were made.

On the 29th of May the balloon was filled early in the afternoon and left at $6^h\ 14^m$, about an hour and three-quarters before sunset, in the hope of being able to remain in the air for as long after sunset as possible.

The temperature of the air at this time was 58°, and was 58½° at Greenwich Observatory. It at once declined to 55° at 1200 feet, and to 43° between the height of 3600 to 4600 feet, then further declining to 29½° at the height of 6200 feet, at $7^h\ 17^m$. On turning to descend, the temperature increased, but not uniformly, to 54° at $8^h\ 9^m$, at 380 feet above the sea, but very nearly touching the tops of the trees, being about 3° of less temperature when at the same height above the sea on rising. Our object was to be as near the earth as possible at the time of sunset, and having seen him set to discharge sand so quickly as to make him to rise in the west. We did not succeed. At the time of sunset we were about 600 feet high, but directly passed over a hill, and on passing the ridge, the balloon was sucked down and, it was only by a very free discharge of sand that Mr. Westcar prevented the balloon coming to the ground. We then again started upon a second ascent, to be as like the one we had just completed as we could make it. At $8^h\ 9^m$ the temperature was 54°. Again the temperature declined, but somewhat less rapidly than before. On again reaching one mile the temperature had declined to 39°, and on reaching the height of 6200 feet (the same elevation as we were three-quarters of an hour before sunset), the sun having set

nearly twenty minutes, the temperature was 35°, or about 6° warmer than when at the same elevation something more than one hour before. On turning to descend, the temperature changed very little, it being 35° to 36° for a thousand feet downwards. It increased to 37° at 4500, to 47° at 1500, and to 54° at 900 feet; but here the increase was checked, and at 600 feet the temperature was 52¾°; on ascending a little again the temperature increased and decreased on descending, and was 50¼° on the ground at a spot 300 feet above the sea, at half-past eight o'clock. At Greenwich at this time the temperature of the air was 52°.

At the time of leaving the earth at 6ʰ 14ᵐ the air at Greenwich had but three grains of moisture in a cubic foot. At Windsor, near the Thames, there were 4½ grains; the air was damp: on ascending the air at first became drier; but at the height of one mile was saturated, and was very nearly saturated at the same height after sunset.

Thus this double ascent enables us to compare the temperatures of the same elevations, just before and just after sunset on the same day, and to estimate the amount of heat radiated from the earth at about the time of sunset.

At heights exceeding 2000 feet the direction of the wind was N. by W.; at the height of one mile the air was nearly calm; and at heights less than 2000 feet it was N. by E., and these currents were met with always at those elevations.

At all times during the ascent, whenever the sun shone upon a transparent bulb, or a dull blackened bulb thermometer, the reading was a very little in excess of the reading of a shaded bulb, and was frequently the same even when the sun's heat felt sensibly warm to ourselves.

The path of the balloon from Windsor was over Windsor Great Park; nearly over Woking at 7ʰ 43ᵐ; a little west of Guildford, approaching the coast, at half-past nine, we calculated that the sea must be near, and we descended at a place five miles south of Pulborough.

My attention was almost wholly occupied with the observations, Mr. Westcar's was chiefly with the management of the balloon, frequently, however, reading the several instruments, particularly those whose bulbs were exposed to the sun's rays.

The safety lamp was burning all the time, thus enabling the instruments to be read after dark.

I till recently believed that this was the first ascent for scientific purposes since that of Biot and Gay-Lussac in 1804, in which the management of the balloon was undertaken by the experimentalists themselves. But I find I am in error in this respect. My friend L'Abbé Moigno tells me that Messrs. Bixio and Barrel, in the year 1850, took the entire management of the balloon in their own hands.

On descending one hour and a half nearly after sunset, there was no one near to assist us to empty the balloon and to pack it. This we had to do ourselves, and were preparing to pass the night in the car of the balloon, when towards midnight a shepherd came to attend sheep, and we passed the night in his cottage at the distance of half a mile, leaving the balloon, &c. in the fields till the morning.

This is the last ascent of which I have to speak. I regret that I have not been able to report upon others, but it is all I have possibly been able to make in the year.

From all the experiments made it would seem that the decrease of temperature with increase of elevation is variable throughout the day, and variable

in the different seasons of the year; that at about sunset the temperature varies but very little for a height of 2000 feet; that at night with a clear sky, from the only experiment made, the temperature increases with increase of elevation; that at night with a cloudy sky there was a small increase of temperature as the height increased; that in the double ascent on May 29, the one just before sunset and the other after, it would seem that after radiation is set in the heat passes upwards till arrested, where the air is saturated with vapour, when a heat greater by 5° was experienced after sunset than at the same elevation before sunset.

Two years ago, when I exhibited the mean results of the experiments then discussed, I did so with much confidence, and thought all that then was needed was to verify the results exhibited. Now, with increased knowledge, I speak very differently, believing that many more experiments are necessary, and that they should not be confined to this country.

Certain it is, from the very remarkable results obtained from the night ascents, which might, with sufficient number of observations, have important bearing both on the theory of astronomic refraction and on the theory of heat, that nocturnal observations deserve repetition and extension.

## § 3. Description of the Table of Observations.

All the meteorological observations taken during the ascents are contained in Table I.

Column 1 contains the times at which the observations were made. Column 2 contains observations of the barometer corrected for temperature and index error. Column 3 contains the height above the level of the sea, as deduced from the barometric readings in column 2, by the formula of Bailey, checked at intervals by that of Laplace, which is as follows:—

$$Z=\log\left(\frac{h'}{h}\right)\times 60159\left(1+\frac{t+t'-64}{900}\right)\left(1+0{\cdot}002837\cos 2L\right)\left(1+\frac{z+52251}{20886900}\right),$$

where Z is the height required, and $h$, $h'$, $t$ and $t'$ the height of the barometer, corrected for temperature, and the temperature of the air at the lower and upper stations respectively, L the latitude. The temperature of the air for the position of the balloon has been derived from the readings in column 4. Columns 5 to 7 contain the observations with wet-bulb thermometer, its depression below the readings of the dry-bulb, and the deduced dew-point.

The Astronomer Royal had observations made every ten minutes at the Royal Observatory, Greenwich, on the days of ascent, by Mr. Nash of the Magnetical and Meteorological Department.

The height of Greenwich barometer cistern above the mean sea-level is 159 feet.

TABLE I. A.—Meteorological Observations made in the Twenty-sixth Balloon Ascent from Woolwich Arsenal, October 2, 1865.

| References to Notes. | Time. | Aneroid Barometer. | Height above sea-level. | Dry and Wet Thermometers (free). | | | |
|---|---|---|---|---|---|---|---|
| | | | | Dry. | Wet. | Diff. | Dew-point. |
| | h m s | in. | feet. | ° | ° | ° | ° |
| (1) | 5 25 0 p.m. | 30·00 | on the ground | 61·2 | 58·4 | 2·8 | 55·9 |
| | 5 35 0 ,, | 30·01 | | 59·8 | 56·4 | 3·4 | 53·5 |
| | 5 45 0 ,, | 30·01 | | 58·8 | 57·0 | 1·8 | 55·4 |
| (2) | 5 55 0 ,, | 30·01 | | 57·8 | 55·9 | 1·9 | 54·2 |
| | 6 15 0 ,, | 30·01 | ..... | 57·0 | | | |
| | 6 16 0 ,, | 30·01 | ..... | 57·0 | | | |
| | 6 17 0 ,, | 30·01 | ..... | 56·5 | | | |
| (3) | 6 20 0 ,, | ..... | ..... | 56·0 | | | |
| (4) | 6 22 0 ,, | 29·90 | 107 | 56+ | | | |
| (5) | 6 25 0 ,, | 28·99 | 967 | 57+ | | | |
| (6) | 6 26 30 ,, | 28·81 | 1,139 | 58·2 | | | |
| | 6 28 0 ,, | 28·68 | 1,266 | 58·7 | 57·2 | 1·5 | 55·9 |
| (7) | 6 29 0 ,, | 28·64 | 1,302 | 58·9 | 57·5 | 1·4 | 56·2 |
| (8) | 6 30 0 ,, | 28·94 | 1,011 | 58·5 | | | |
| (9) | 6 31 0 ,, | 28·94 | 1,011 | 58·2 | 56·5 | 1·7 | 55·0 |
| (10) | 6 32 0 ,, | ..... | ..... | 58·0 | 56·5 | 1·5 | 55·2 |
| (11) | 6 33 0 ,, | 29·24 | 727 | 57·8 | 57·0 | 0·8 | 56·3 |
| (12) | 6 35 0 ,, | 28·99 | 967 | 57·8 | 57·0 | 0·8 | 56·3 |
| (13) | 6 36 0 ,, | 28·69 | 1,255 | 58·2 | 57·2 | 1·0 | 56·3 |
| | 6 37 0 ,, | 28·62 | 1,323 | 57·8 | 57·2 | 0·6 | 56·7 |
| (14) | 6 38 0 ,, | 28·64 | 1,304 | 58·0 | 57·2 | 0·8 | 56·5 |
| | 6 40 0 ,, | 28·62 | 1,322 | 58·0 | 57·3 | 0·7 | 56·6 |
| (15) | 6 41 0 ,, | 28·53 | 1,409 | 58·0 | 57·3 | 0·7 | 56·6 |
| (16) | 6 42 0 ,, | 28·56 | 1,380 | 57·8 | 57·2 | 0·6 | 56·7 |
| (17) | 6 43 0 ,, | 28·54 | 1,399 | 58·2 | 57·5 | 0·7 | 56·9 |
| (18) | 6 45 0 ,, | 28·56 | 1,380 | 58·2 | 57·5 | 0·7 | 56·9 |
| (19) | 6 46 0 ,, | 28·61 | 1,331 | 58·2 | 57·3 | 0·9 | 54·6 |
| (20) | 6 47 0 ,, | | | | | | |
| | 6 48 30 ,, | 28·64 | 1,302 | 58·2 | | | |
| | 6 50 0 ,, | 28·69 | 1,254 | 58·0 | 57·4 | 0·6 | 56·9 |
| (21) | 6 51 0 ,, | | | | | | |
| (22) | 6 52 0 ,, | 28·64 | 1,302 | 58·0 | 57·4 | 0·6 | 56·9 |
| | 6 53 0 ,, | 28·64 | 1,302 | 58·0 | 57·5 | 0·5 | 57·0 |
| | 1. | 2. | 3. | 4. | 5. | 6. | 7. |

(1) Fixed a flat piece of cotton-wool on end of the supporting frame, and placed on it the bulb of a delicate minimum thermometer, with its bulb fully exposed to the sky; and placed a second minimum thermometer with its bulb projecting into space, and also fully exposed to the sky. (2) In the balloon just before starting.
(3) Left the earth, and found I could not read the instruments.
(4) Can just see the temperature is more than 56°.
(5) Have just succeeded in seeing that the temperature is above 57°.
(6) Can see better. (7) Nearly opposite Victoria Docks.
(8) Off Brunswick Pier, Blackwall. (9) Over the Thames.
(10) Light of moon across the river very grand.
(11) Over the Isle of Dogs; most difficult to write.
(12) Over the River Thames again. (13) London Bridge in sight.
(14) Our course is almost directly up the river.
(15) The minimum thermometer on wool near 58°, and that in air near 58°.
(16) Over South-Eastern Railway Station, London Bridge.
(17) Over Southwark Bridge. (18) Over Blackfriars Bridge.
(19) Nearly over Hungerford Railway Station.
(20) Can see people walking along the streets. Reflexion of light very remarkable indeed. Nearly over Oxford Street. (21) Over Marble Arch.
(22) Passing between Edgeware Road and Bayswater Road.

TABLE I. A.—(*continued*).

| References to Notes. | Time. | Aneroid Barometer. | Height above sea-level. | Dry and Wet Thermometers (free). | | | |
|---|---|---|---|---|---|---|---|
| | | | | Dry. | Wet. | Diff. | Dew-point. |
| | h m s | in. | feet. | ° | ° | ° | ° |
| (1) | 6 54 0 p.m. | 28·38 | 1,552 | 58·9 | 57·9 | 1·0 | 57·0 |
| (2) | 6 55 0 ,, | 28·14 | 1,785 | 59·0 | 58·2 | 0·8 | 57·5 |
| | 6 56 0 ,, | 27·97 | 1,949 | 59·6 | 58·6 | 1·0 | 57·8 |
| (3) | 6 58 0 ,, | 28·45 | 1,488 | 59·0 | 58·1 | 0·9 | 57·3 |
| | 7 0 0 ,, | 28·76 | 1,191 | 59·3 | 58·1 | 1·2 | 57·1 |
| | 7 2 0 ,, | 28·66 | 1,286 | 58·8 | 57·2 | 1·6 | 55·8 |
| (4) | 7 4 0 ,, | 28·84 | 1.115 | 58·7 | 57·6 | 1·1 | 56·5 |
| | 7 5 0 ,, | 28·83 | 1,124 | 58·7 | 57·6 | 1·1 | 56·5 |
| (5) | 7 7 0 ,, | 28·84 | 1,115 | 58·6 | 57·6 | 1·0 | 56·7 |
| | 7 9 0 ,, | 28·84 | 1,115 | 58·6 | 57·4 | 1·2 | 56·3 |
| | 7 11 0 ,, | 29·04 | 925 | 58·6 | 57·4 | 1·2 | 56·3 |
| | 7 12 0 ,, | 28·99 | 970 | 58·7 | | | |
| | 7 15 0 ,, | 29·04 | 925 | 58·2 | 56·8 | 1·4 | 55·5 |
| (6) | 7 16 0 ,, | 29·14 | 835 | 57·2 | 55·8 | 1·4 | 54·5 |
| | 7 17 0 ,, | 29·19 | 790 | 57·3 | 55·8 | 1·5 | 54·3 |
| (7) | 7 18 0 ,, | 29·34 | 655 | 57·5 | 56·2 | 1·3 | 55·0 |
| (8) | 7 19 0 ,, | 29·04 | 925 | 58·2 | 55·6 | 2·6 | 53·2 |
| | 7 21 0 ,, | 29·09 | 880 | 58·8 | 56·9 | 1·9 | 55·2 |
| | 7 22 0 ,, | 29·24 | 745 | 58·2 | 56·8 | 1·4 | 55·5 |
| | 7 24 0 ,, | 29·16 | 817 | | | | |
| | 7 27 0 ,, | 29·16 | 817 | 58·5 | 56·5 | 2·0 | 54·7 |
| | 7 30 0 ,, | 29·16 | 817 | 58·5 | 57·0 | 1·5 | 55·6 |
| | 7 32 0 ,, | 29·34 | 637 | 58·0 | 56·7 | 1·3 | 55·5 |
| | 7 35 0 ,, | 29·44 | 537 | 57·6 | 56·1 | 1·5 | 54·8 |
| | 7 37 0 ,, | 29·24 | 736 | 58·0 | 56·5 | 1·5 | 55·2 |
| | 7 39 0 ,, | 29·03 | 947 | 58·6 | | | |
| | 7 44 0 ,, | 29·55 | 519 | 57·2 | 56·2 | 1·0 | 55·3 |
| | 7 46 0 ,, | 29·44 | 618 | 57·1 | 55·0 | 2·2 | 52·9 |
| (9) | 7 48 0 ,, | 29·39 | 663 | 58·0 | 55·8 | 2·2 | 54·7 |
| (10) | 7 50 0 ,, | 29·16 | 802 | 58·0 | 55·9 | 2·1 | 54·9 |
| | 7 52 0 ,, | 29·06 | 898 | 58·7 | | | |
| | 7 55 0 ,, | 28·94 | 1,029 | 58·4 | 56·0 | 2·4 | 53·8 |
| (11) | 7 58 0 ,, | 28·94 | 1,029 | 58·5 | | | |
| | 8 0 0 ,, | 29·24 | 751 | 56·8 | 54·6 | 2·2 | 52·5 |
| (12) | 8 2 0 ,, | 29·44 | 561 | 57·0 | | | |
| (13) | 8 4 0 ,, | 29·36 | 637 | 57·2 | 55·5 | 1·7 | 54·0 |
| | 8 10 0 ,, | 29·14 | 846 | 57·7 | | | |
| (14) | 8 12 0 ,, | 29·36 | 637 | 56·9 | 54·5 | 2·4 | 52·3 |
| | 8 15 0 ,, | 29·09 | 890 | 57·2 | 55·0 | 2·2 | 53·0 |
| (15) | 8 16 0 ,, | 29·24 | 756 | 57·5 | 54·9 | 2·6 | 52·4 |
| | 8 18 0 ,, | 29·61 | 403 | 57·3 | 56·0 | 1·3 | 54·8 |
| (16) | 8 20 0 ,, | ..... | ground. | 56·0 | | | |
| | 1. | 2. | 3. | 4. | 5. | 6. | 7. |

(1) Thermometer on wool 58°. (2) Thermometer with projecting bulb in space 58°.
(3) Leaving London; great contrast looking towards London and looking towards Uxbridge, the direction in which we are going nearly. (4) Misty and very dark.
(5) Misty. (6) Changed direction. Can see the shadow of the balloon on the ground.
(7) Loud cheering heard. (8) The shadow of the balloon on the ground is very dark.
(9) Instruments difficult to read. (10) Crossing the River Thames.
(11) Over a wood. (12) Can see valve of the balloon.
(13) Over water, crossing the River Thames again.
(14) Can just see a Lyræ at the boundary of the balloon.
(15) Over very wooded country.
(16) Descended on a farm at Highmoor, in Oxfordshire, nine miles from Reading and five miles from Henley-upon-Thames.

TABLE I. B.—Meteorological Observations made in the Twenty-seventh Balloon Ascent from Woolwich Arsenal, December 2, 1865.

| References to Notes. | Time. | Aneroid Barometer. | Height above sea-level. | Dry and Wet Thermometers (free). | | | |
|---|---|---|---|---|---|---|---|
| | | | | Dry. | Wet. | Diff. | Dew-point. |
| | h m s | in. | feet. | ° | ° | ° | ° |
| (1) | 5 0 0 p.m. | 29·68 | on the ground | 38·8 | 38·0 | 0·8 | 37·0 |
| | 5 8 0 „ | 29·68 | | 39·0 | 38·1 | 0·9 | 36·9 |
| | 5 9 0 „ | 29·68 | | 39·0 | 38·0 | 1·0 | 36·7 |
| | 5 11 0 „ | 29·68 | | 39·0 | 38·0 | 1·0 | 36·7 |
| | 5 14 0 „ | 29·68 | | 38·5 | 38·0 | 0·5 | 37·4 |
| (2) | 5 15 0 „ | 29·68 | | 38·3 | 38·0 | 0·3 | 37·6 |
| (3) | 5 16 0 „ | 29·38 | 320 | 36·6 | 36·2 | 0·4 | 35·7 |
| (4) | 5 17 0 „ | 28·23 | 1,410 | 36·2 | 36·0 | 0·2 | 35·7 |
| | 5 18 0 „ | 28·15 | 1,485 | 36·2 | 36·0 | 0·2 | 35·7 |
| (5) | 5 19 0 „ | 28·13 | 1,504 | 36·2 | 36·2 | 0·0 | 36·2 |
| | 5 20 0 „ | 28·13 | 1,504 | 36·2 | 36·0 | 0·2 | 35·7 |
| | 5 21 0 „ | 28·03 | 1,598 | 36·3 | 36·2 | 0·1 | 36·0 |
| (6) | 5 22 0 „ | 28·33 | 1,316 | 36·3 | 36·2 | 0·1 | 36·0 |
| | 5 24 0 „ | 28·38 | 1,269 | 36·2 | 35·8 | 0·4 | 35·3 |
| (7) | 5 25 0 „ | 28·38 | 1,269 | 36·5 | | | |
| | 5 26 0 „ | 28·28 | 1,363 | 36·6 | 36·5 | 0·1 | 36·4 |
| | 5 27 0 „ | 28·23 | 1,410 | 36·7 | 36·6 | 0·1 | 36·5 |
| | 5 29 0 „ | 27·98 | 1,643 | 36·3 | 36·0 | 0·3 | 35·5 |
| | 5 30 0 „ | 27·93 | 1,692 | 36·4 | 35·9 | 0·5 | 35·2 |
| | 5 31 0 „ | 27·98 | 1,642 | 37·2 | 37·0 | 0·2 | 36·7 |
| (8) | 5 32 0 „ | 28·00 | 1,625 | 36·6 | 37·0 | | |
| (9) | 5 32 + „ | 28·08 | 1,548 | | | | |
| | 5 33 0 „ | 28·01 | 1,615 | 36·6 | 36·6 | 0·0 | 36·6 |
| | 5 34 0 „ | 27·93 | 1,692 | 36·7 | 36·6 | 0·1 | 36·5 |
| | 5 35 0 „ | 27·93 | 1,692 | 36·6 | 36·6 | 0·0 | 36·6 |
| (10) | 5 36 0 „ | 27·68 | 1,930 | 36·3 | 36·2 | 0·1 | 36·0 |
| | 5 37 0 „ | 27·58 | 2,025 | 36·2 | 36·0 | 0·2 | 35·7 |
| | 5 38 0 „ | 27·52 | 2,083 | 36·0 | 35·8 | 0·2 | 35·5 |
| | 5 38 + „ | 27·48 | 2,121 | 36·5 | 36·3 | 0·2 | 36·0 |
| | 5 39 0 „ | 27·83 | 1,788 | 37·0 | 36·8 | 0·2 | 36·6 |
| (11) | 5 40 0 „ | 27·88 | 1,741 | 37·3 | 37·0 | 0·3 | 36·6 |
| | 5 41 0 „ | 27·93 | 1,692 | 37·6 | 37·2 | 0·4 | 36·7 |
| (12) | 5 44 0 „ | 27·93 | 1,692 | 37·5 | 37·2 | 0·3 | 36·8 |
| | 5 45 0 „ | 27·73 | 1,882 | 37·2 | 37·2 | 0·0 | 37·2 |
| | 5 46 0 „ | 27·53 | 2,072 | 35·0 | 35·2 | | |
| | 5 47 0 „ | 27·28 | 2,323 | 34·2 | 34·0 | 0·2 | 33·7 |
| (13) | 5 47 + „ | 27·08 | 2,522 | 34·2 | 34·2 | 0·0 | 34·2 |
| | 5 48 0 „ | 26·98 | 2,601 | 34·0 | 34·0 | 0·0 | 34·0 |
| | 5 49 0 „ | 26·98 | 2,601 | 34·0 | 34·0 | 0·0 | 34·0 |
| (14) | 5 50 0 „ | 27·13 | 2,457 | 34·2 | 34·2 | 0·0 | 34·2 |
| | 1. | 2. | 3. | 4. | 5. | 6. | 7. |

(1) Let off a pilot balloon, which took the direction of N.W.
(2) Left the earth. (3) Misty all round.
(4) Damp to sense; cannot see London.
(5) Going in the direction of W. by N.; can see Woolwich, Greenwich, &c., but not London.
(6) Going towards Stratford.
(7) Near Commercial Road; can see its long line of lights.
(8) Discharged sand, about 14 lbs. in weight, and caused us to rise about 550 feet.
(9) Both radiation thermometers near 28°. (10) A densely cloudy sky.
(11) Cloudy; nothing visible.
(12) Earth dotted with large white clouds; some of them miles in extent.
(13) Moving N.W. by compass. (14) Gas clear.

TABLE I. B (*continued*).

| References to Notes. | Time. | Aneroid Barometer. | Height above sea-level. | Dry and Wet Thermometers (free). | | | |
|---|---|---|---|---|---|---|---|
| | | | | Dry. | Wet. | Diff. | Dew-point. |
| | h m s | in. | feet. | ° | ° | ° | ° |
| | 5 50 30 p.m. | 27·44 | 2,157 | 34·8 | 34·2 | 0·6 | 34·2 |
| | 5 51 0 „ | 27·51 | 2,088 | 35·0 | 34·9 | 0·1 | 34·8 |
| | 5 52 0 „ | 27·53 | 2,068 | 34·8 | 34·0 | 0·8 | 32·7 |
| | 5 53 0 „ | 27·53 | 2,068 | 34·8 | 34·6 | 0·2 | 34·3 |
| | 5 54 0 „ | 27·48 | 2,316 | 34·5 | 34·3 | 0·2 | 34·0 |
| (1) | 5 55 0 „ | | | | | | |
| | 5 56 30 „ | 27·01 | 2,560 | 32·8 | 33·0 | | |
| (2) | 5 58 0 „ | 26·98 | 2,589 | 32·7 | 32·6 | 0·1 | 32·4 |
| | 5 59 0 „ | 26·98 | 2,589 | 32·7 | 32·5 | 0·2 | 32·1 |
| (3) | 6 0 0 „ | 27·03 | 2,541 | 32·7 | 32·5 | 0·2 | 32·1 |
| | 6 1 0 „ | 27·08 | 2,492 | 33·0 | 33·0 | 0·0 | 33·0 |
| | 6 2 0 „ | 26·83 | 2,736 | 33·0 | 33·0 | 0·0 | 33·0 |
| (4) | 6 3 0 „ | 26·65 | 2,909 | 33·0 | 33·0 | 0·0 | 33·0 |
| (5) | 6 4 0 „ | 26·63 | 2,929 | 33·0 | 32·8 | 0·2 | 32·4 |
| | 6 5 0 „ | 26·61 | 2,949 | 33·1 | 32·9 | 0·2 | 32·5 |
| | 6 6 0 „ | 26·58 | 2,978 | 33·0 | 32·7 | 0·3 | 32·1 |
| | 6 6 30 „ | 26·53 | 3,032 | 33·1 | 32·6 | 0·5 | 31·6 |
| | 6 7 0 „ | 26·53 | 3,032 | 33·3 | 32·9 | 0·4 | 32·2 |
| (6) | 6 8 0 „ | 26·63 | 2,934 | 33·3 | | | |
| (7) | 6 8 30 „ | 26·38 | 3,179 | 34·0 | 31·7 | 2·3 | 27·7 |
| (8) | 6 9 0 „ | 26·33 | 3,228 | 32·4 | 32·0 | 0·4 | 31·2 |
| | 6 10 0 „ | 26·33 | 3,228 | 32·0 | 31·7 | 0·3 | 31·0 |
| (9) | 6 11 0 „ | | | | | | |
| (10) | 6 12 0 „ | 26·43 | 3,130 | 32·7 | 32·2 | 0·5 | 31·3 |
| | 6 13 0 „ | 26·58 | 2,980 | 32·8 | 32·2 | 0·6 | 31·1 |
| | 6 14 0 „ | 26·61 | 2,950 | 33·3 | 33·0 | 0·3 | 32·5 |
| | 6 15 0 „ | 26·65 | 2,910 | 33·5 | 32·3 | 0·2 | 30·1 |
| (11) | 6 16 0 „ | 26·88 | 2,680 | 33·4 | 32·7 | 0·7 | 31·4 |
| (12) | 6 17 0 „ | 27·13 | 2,443 | 34·0 | 33·5 | 0·5 | 32·6 |
| (13) | 6 18 0 „ | 26·68 | 2,883 | 32·8 | 32·3 | 0·5 | 30·7 |
| (14) | 6 22 0 „ | 26·08 | 3,477 | 29·5 | 27·8 | 1·7 | 22·1 |
| (15) | 6 23 0 „ | 26·01 | 3,546 | 29·4 | 27·2 | 2·2 | 19·8 |
| | 6 24 0 „ | 25·91 | 3,646 | 29·5 | 27·3 | 2·2 | 20·0 |
| | 6 25 0 „ | 25·88 | 3,675 | 29·6 | 27·4 | 2·2 | 20·3 |
| | 6 26 0 „ | 25·88 | 3,675 | 29·6 | 27·5 | 2·1 | 20·7 |
| | 6 27 0 „ | 25·97 | 3,585 | 30·0 | 29·5 | 0·5 | 27·9 |
| (16) | 6 28 0 „ | 26·13 | 3,425 | 31·1 | 30·0 | 1·1 | 27·1 |
| | 6 29 0 „ | 26·23 | 3,325 | 31·2 | 30·0 | 1·2 | 26·9 |
| (17) | 6 30 0 „ | 26·35 | 3,206 | 31·2 | 30·0 | 1·2 | 26·9 |
| | 6 31 0 „ | 26·35 | 3,206 | 31·2 | 29·9 | 1·3 | 26·6 |
| | 1. | 2. | 3. | 4. | 5. | 6. | 7. |

(1) Clouds under us look very fine; fields and their boundaries very clear; can hear clock striking; sand thrown out. (2) 45 seconds crossing a field. (3) Sand thrown out.
(4) Uniform dense cloud obscuring the moon and every star.
(5) Large detached clouds under. (6) Sky cloudy above.
(7) Detached clouds in many places over land. (8) Fine appearance.
(9) Thermometer on wool read 23°·5, that in space 20°·5.
(10) Cannot see moon; direction by compass N.W.
(11) Thermometer on wool 23°·5, that in space 20°·3. (12) Sand discharged.
(13) Near Tring; entered a different current of wind and changed direction to N.N.E., a S.S.W. wind. (14) Railway train appears like a meteor.
(15) Cold to sense. (16) Sand discharged.
(17) A town visible nearly to the N. of us; ? Dunstable.

TABLE I. B (*continued*.)

| Reference to Notes. | Time. | Aneroid Barometer. | Height above sea-level. | Dry and Wet Thermometers (free). | | | |
|---|---|---|---|---|---|---|---|
| | | | | Dry. | Wet. | Diff. | Dew point. |
| | h m s | in. | feet. | ° | ° | ° | ° |
| (1) | 6 32 0 p.m. | 26·13 | 3,426 | 30·9 | 29·0 | 1·9 | 23·8 |
| | 6 33 0 „ | 25·95 | 3,606 | 29·2 | 28·2 | 1·0 | 24·7 |
| (2) | 6 34 0 „ | 25·73 | 3,826 | 27·8 | 26·2 | 1·6 | 19·5 |
| | 6 35 0 „ | 25·71 | 3,846 | 27·8 | 26·2 | 1·6 | 19·5 |
| | 6 36 0 „ | 25·55 | 4,003 | 27·5 | 26·2 | 1·3 | 20·7 |
| (3) | 6 38 0 „ | 25·43 | 4,126 | 27·2 | 26·5 | 0·7 | 23·4 |
| | 6 39 0 „ | 25·15 | 4,406 | 27·2 | 26·2 | 1·0 | 21·7 |
| (4) | 6 39 30 „ | 24·93 | 4,628 | 27·2 | 26·2 | 1·0 | 21·7 |
| | 6 40 0 „ | 25·13 | 4,428 | 27·2 | 26·0 | 1·2 | 20·7 |
| (5) | 6 41 0 „ | 25·28 | 4,278 | 27·7 | 27·2 | 0·5 | 25·3 |
| | 6 42 0 „ | 25·88 | 3,678 | 29·9 | 28·5 | 1·4 | 24·0 |
| (6) | 6 43 0 „ | 26·01 | 3,542 | 30·0 | 29·0 | 1·0 | 25·9 |
| | 6 44 0 „ | 26·08 | 3,478 | 30·5 | 29·6 | 0·9 | 27·1 |
| | 6 45 0 „ | 26·43 | 3,128 | 31·0 | 30·3 | 0·7 | 28·4 |
| (7) | 6 46 0 „ | 26·93 | 2,628 | 32·0 | 31·5 | 0·5 | 30·3 |
| | 6 47 0 „ | 27·13 | 2,428 | 32·5 | 32·0 | 0·5 | 31·0 |
| (8) | 6 48 0 „ | 27·18 | 2,378 | | | | |
| | 7 10 0 „ | 29·30 | on ground. | 40·2 | 39·3 | 0·9 | 38·2 |

TABLE I. C.—Meteorological Observations made in the Twenty-eighth Balloon Ascent, from Windsor, May 29, 1866.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| (9) | 6 12 0 p.m. | 29·88 | ground. | 58·0 | 55·0 | 3·0 | 51·3 |
| | 6 14 30 „ | 29·31 | 562 | 57·2 | 55·1 | 2·1 | 53·2 |
| | 6 15 0 „ | 28·56 | 1,247 | 55·2 | 53·1 | 2·1 | 51·1 |
| (10) | 6 16 0 „ | 28·46 | 1,340 | 54·7 | 52·5 | 2·2 | 50·3 |
| (11) | 6 17 0 „ | ..... | ..... | 53·5 | 51·0 | 2·5 | 48·5 |
| | 6 17 30 „ | 28·01 | 1,782 | 52·5 | 48·1 | 4·4 | 43·6 |
| | 6 18 0 „ | 27·86 | 1,929 | 52·5 | 47·1 | 5·4 | 41·6 |
| (12) | 6 19 0 „ | 27·76 | 2,027 | 52·2 | 46·5 | 5·7 | 40·7 |
| (13) | 6 20 0 „ | 27·76 | 2,027 | 52·8 | 47·2 | 5·6 | 41·5 |
| | 6 21 0 „ | 27·88 | 1,908 | 52·2 | 47·5 | 4·7 | 43·7 |
| (14) | 6 21 30 „ | 27·96 | 1,829 | 53·0 | 47·0 | 6·0 | 41·0 |
| | 6 21 45 „ | 27·96 | 1,829 | 52·7 | 47·0 | 5·7 | 41·2 |
| | 6 22 0 „ | 27·77 | 2,017 | 52·5 | 47·3 | 5·2 | 42·0 |
| | 6 23 0 „ | 27·56 | 2,223 | 50·2 | 45·0 | 5·2 | 39·5 |
| | 1. | 2. | 3. | 4. | 5. | 6. | 7. |

(1) Thermometer on wool 21°, that in space 19°.
(2) Thermometer on wool 20½°, that in space 18½°. (3) Sand discharged.
(4) Beautiful appearance of detached clouds on earth.
(5) Black clouds, and very high, completely cover the sky above.
(6) Moon visible; still moving N.N.W., both by the moon and compass.
(7) Changed direction; moving S.E.
(8) Whilst supplying the wet-bulb thermometer with water I fell against the lamp, and it was extinguished; came to the ground at 7 o'clock at Ridgemouth, near Woburn, Bedfordshire.
(9) Left the earth.
(10) Direction due S.
(11) Thermometer in sun reads 53°.
(12) Fine view of Ascot Racecourse to S.W.
(13) The numerous hawthorn trees in blossom are like snowballs on the ground. The sckened bulb thermometer in sun reads 49°.
(14) Sand discharged.

TABLE I. c (*continued*).

| References to Notes. | Time. | Aneroid Barometer. | Height above sea-level. | Dry and Wet Thermometers (free). | | | |
|---|---|---|---|---|---|---|---|
| | | | | Dry. | Wet. | Diff. | Dew-point. |
| | h m s | in. | feet. | ° | ° | ° | ° |
| | 6 24 0 p.m. | 27·31 | 2,469 | 49·2 | 44·8 | 4·4 | 40·0 |
| (1) | 6 27 0 „ | 27·06 | 2,715 | 48·0 | 44·0 | 4·0 | 39·6 |
| (2) | 6 31 30 „ | 26·81 | 2,961 | 47·5 | 44·0 | 3·5 | 40·1 |
| (3) | 6 32 0 „ | 26·81 | 2,961 | 47·2 | 44·0 | 3·2 | 40·4 |
| | 6 33 0 „ | 26·68 | 3,093 | 46·8 | 44·0 | 2·8 | 40·9 |
| (4) | 6 36 0 „ | 26·61 | 3,171 | 47·2 | 43·1 | 4·1 | 38·5 |
| (5) | 6 37 0 „ | 26·51 | 3,276 | 48·2 | 42·1 | 6·1 | 35·4 |
| (6) | 6 39 0 „ | 26·37 | 3,418 | 48·9 | 42·0 | 6·9 | 34·5 |
| | 6 40 0 „ | 26·31 | 3,481 | 47·2 | 41·5 | 5·7 | 35·1 |
| | 6 43 0 „ | 26·01 | 3,796 | 47·2 | 42·0 | 5·2 | 36·2 |
| (7) | 6 45 0 „ | 25·96 | 3,848 | 46·2 | 41·5 | 4·7 | 36·1 |
| | 6 46 0 „ | 25·91 | 3,900 | 43·6 | 40·0 | 3·6 | 35·8 |
| | 6 47 0 „ | 25·78 | 4,036 | 43·5 | 39·3 | 4·2 | 34·3 |
| (8) | 6 48 0 „ | 25·56 | 4,264 | 43·2 | 39·8 | 3·4 | 35·8 |
| | 6 51 0 „ | 25·51 | 4,316 | 43·5 | 40·0 | 3·5 | 35·9 |
| | 6 52 0 „ | 25·46 | 4,368 | 43·3 | 40·2 | 3·1 | 36·5 |
| | 6 53 0 „ | 25·38 | 4,447 | 43·2 | 40·1 | 3·1 | 36·4 |
| | 6 54 0 „ | 25·26 | 4,572 | 41·5 | 39·5 | 2·0 | 37·0 |
| (9) | 6 55 0 „ | 25·16 | 4,675 | 39·0 | 39·0 | 0·0 | 39·0 |
| | 6 56 0 „ | 25·21 | 4,623 | 39·5 | 39·0 | 0·5 | 38·4 |
| (10) | 6 57 0 „ | 25·36 | 4,467 | 40·5 | 38·7 | 1·8 | 35·3 |
| (11) | 6 58 0 „ | 25·41 | 4,415 | 40·9 | 38·2 | 2·7 | 34·7 |
| | 6 59 0 „ | 25·43 | 4,394 | 41·0 | 38·1 | 2·9 | 34·4 |
| | 7 0 0 „ | ..... | ..... | 39·2 | 37·5 | 1·7 | 35·3 |
| (12) | 7 1 0 „ | 24·91 | 4,934 | 38·0 | 36·5 | 1·5 | 34·5 |
| | 7 2 0 „ | 24·77 | 5,078 | 37·2 | 36·1 | 1·1 | 34·6 |
| | 7 3 0 „ | 24·67 | 5,182 | 37·2 | 35·0 | 2·2 | 32·2 |
| | 7 4 0 „ | 24·41 | 5,469 | 35·0 | 34·5 | 0·5 | 33·7 |
| | 7 6 0 „ | 24·40 | 5,480 | 34·5 | 34·0 | 0·5 | 33·2 |
| | 7 7 0 „ | 24·16 | 5,739 | 35·0 | 34·5 | 0·5 | 33·7 |
| (13) | 7 8 0 „ | 24·16 | 5,739 | 35·2 | 34·1 | 1·1 | 32·4 |
| | 1. | 2. | 3. | 4. | 5. | 6. | 7. |

(1) Misty; course still almost due S.
(2) Can hear the voices of boys calling out in Long Walk.
(3) Wonderfully wooded country. Over Virginia Water; can see ripples on the water. Blackened bulb thermometer reads 44°, and a transparent bulb 45°·2; the sun is shining on the bulbs.
(4) Still moving S.; sun shining brightly; blackened bulb 43°·1; minimum radiation 39°·2.
(5) Can see train on the South-Western line; appearance like a caterpillar; at 6h 40m just out of mist.
(6) Sun warm to sense; misty below; blue sky above; cannot see far; plain thermometer in sun reads 45°·2; the blackened bulb 44°·5.
(7) Having supplied water to the wet-bulb, the wet-finger steamed, and steam surrounded Mr. Westcar's hand.
(8) The thermometer, with its bulb exposed to the sun, reads 41°·5; the minimum thermometer reads 37°.
(9) Mr. Westcar remarked that it had suddenly become damp to sense.
(10) The sun discerned; misty.
(11) The transparent bulb reads 36°; the minimum thermometer on stand reads 36°.
(12) Gas clear; sun behind clouds.
(13) The blackened bulb thermometer reads 33°; the transparent bulb beside it reads 32°; and the minimum on stand reads 32°.

TABLE I. c (*continued*).

| References to Notes. | Time. | Aneroid Barometer. | Height above sea-level. | Dry and Wet Thermometers (free). | | | |
|---|---|---|---|---|---|---|---|
| | | | | Dry. | Wet. | Diff. | Dew-point. |
| | h m s | in. | feet. | ° | ° | ° | ° |
| | 7 9 0 p.m. | 24·14 | 5,760 | 35·0 | 34·1 | 0·9 | 32·7 |
| (1) | 7 10 0 „ | 24·14 | 5,760 | 35·2 | 33·6 | 1·6 | 31·2 |
| | 7 11 0 „ | 24·21 | 5,673 | 35·7 | 33·7 | 2·0 | 30·7 |
| (2) | 7 12 0 „ | 24·36 | 5,489 | 36·0 | 33·5 | 2·5 | 29·8 |
| (3) | 7 13 0 „ | ..... | ..... | ..... | ..... | ..... | ..... |
| | 7 14 0 „ | 24·15 | 5,778 | 31·8 | 30·0 | 1·8 | 25·8 |
| | 7 15 0 „ | 24·06 | 5,832 | 31·0 | 30·0 | 1·0 | 27·3 |
| | 7 16 0 „ | 23·91 | 5,999 | 30·5 | 29·1 | 1·4 | 25·1 |
| | 7 17 0 „ | 23·76 | 6,162 | 29·5 | 28·0 | 1·5 | 23·0 |
| | 7 18 0 „ | 23·61 | 6,325 | 29·5 | 28·0 | 1·5 | 23·0 |
| | 7 19 0 „ | 23·66 | 6,271 | 30·0 | 28·3 | 1·7 | 23·0 |
| | 7 20 0 „ | 23·76 | 6,162 | 30·5 | 28·5 | 2·0 | 22·8 |
| | 7 21 0 „ | 23·86 | 6,053 | 31·0 | 28·0 | 3·0 | 19·8 |
| | 7 22 0 „ | 23·91 | 5,998 | 31·5 | 28·7 | 2·8 | 22·8 |
| (4) | 7 23 0 „ | 23·98 | 5,922 | 32·0 | 29·5 | 2·5 | 23·7 |
| (5) | 7 24 0 „ | 23·88 | 6,031 | 31·8 | 29·2 | 2·6 | 23·0 |
| | 7 25 0 „ | ..... | ..... | ..... | ..... | ..... | ..... |
| | 7 26 0 „ | 24·11 | 5,790 | 31·8 | 30·0 | 1·8 | 25·8 |
| (6) | 7 27 0 „ | 24·26 | 5,617 | 32·2 | 31·5 | 0·7 | 30·1 |
| | 7 28 0 „ | 24·41 | 5,454 | 33·0 | 31·2 | 1·8 | 27·6 |
| | 7 29 0 „ | 24·51 | 5,350 | 33·0 | 31·2 | 1·8 | 27·6 |
| | 7 30 0 „ | 24·66 | 5,197 | 33·2 | 31·0 | 2·2 | 26·7 |
| | 7 31 0 „ | 24·76 | 5,078 | 34·0 | 31·2 | 2·8 | 26·2 |
| | 7 32 0 „ | 24·81 | 5,025 | 34·5 | 31·8 | 2·7 | 27·3 |
| (7) | 7 33 0 „ | 24·91 | 4,919 | 34·5 | 32·2 | 2·3 | 28·3 |
| | 7 34 0 „ | 25·28 | 4,526 | 35·5 | 33·1 | 2·4 | 29·4 |
| (8) | 7 35 0 „ | 25·37 | 4,431 | 36·0 | 34·2 | 1·8 | 31·5 |
| (9) | 7 36 0 „ | 25·46 | 4,336 | ..... | ..... | ..... | ..... |
| | 7 37 0 „ | 25·58 | 4,209 | 36·2 | 34·7 | 1·5 | 33·3 |
| | 7 38 0 „ | 25·76 | 4,019 | 36·2 | 35·0 | 1·2 | 33·2 |
| | 7 39 0 „ | 25·86 | 3,918 | 37·1 | 35·8 | 1·3 | 34·0 |
| | 7 40 0 „ | 26·16 | 3,615 | 38·0 | 36·5 | 1·5 | 34·5 |
| | 7 41 0 „ | 26·31 | 3,463 | 38·9 | 36·7 | 2·2 | 33·8 |
| | 7 42 0 „ | 26·51 | 3,261 | 39·2 | 37·0 | 2·2 | 34·1 |
| (10) | 7 43 0 „ | 26·54 | 3,230 | 40·5 | 37·5 | 3·0 | 35·7 |
| | 7 44 0 „ | 27·06 | 2,716 | 41·1 | 37·8 | 3·3 | 33·7 |
| | 7 45 0 „ | 27·11 | 2,669 | 41·1 | 38·0 | 3·1 | 34·1 |
| (11) | 7 46 0 „ | 27·11 | 2,669 | 42·0 | 38·5 | 3·5 | 34·2 |
| | 7 47 0 „ | 27·38 | 2,407 | 43·5 | 40·0 | 3·5 | 35·8 |
| | 7 48 0 „ | 27·46 | 2,329 | 44·0 | 40·2 | 3·8 | 35·7 |
| | 7 49 0 „ | 27·65 | 2,142 | 44·9 | 40·3 | 4·6 | 34·9 |
| | 7 50 0 „ | 27·86 | 1,937 | 44·9 | 40·5 | 4·4 | 35·4 |
| (12) | 7 51 0 „ | 27·98 | 1,821 | 45·0 | 40·9 | 4·1 | 36·2 |
| | 1. | 2. | 3. | 4. | 5. | 6. | 7. |

(1) Gas misty. (2) The minimum radiation thermometer reads 31°.
(3) Near Woking; moving very slowly. (4) Golden spangles in water.
(5) Let off parachute; fell slowly and very prettily.
(6) The minimum radiation thermometer reads 27°·7.
(7) Golden rays of sun shining on water again.
(8) The minimum radiation thermometer reads 31°.
(9) Approaching Guildford very slowly; Aldershot in distance; main line of South-Western Railway nearly under us.
(10) Over cemetery near Woking; the minimum radiation thermometer reads 25°.
(11) Let off parachute. (12) Waterfall visible to the left.

TABLE I. c (*continued*).

| References to Notes. | Time. | Aneroid Barometer. | Height above sea-level. | Dry and Wet Thermometers (free). | | | |
|---|---|---|---|---|---|---|---|
| | | | | Dry. | Wet. | Diff. | Dew-point. |
| | h m s | in. | feet. | ° | ° | ° | ° |
| (1) | 7 52 0 p.m. | 28·36 | 1,457 | 46·2 | 42·0 | 4·2 | 37·2 |
| (2) | 7 53 0 ,, | 28·43 | 1,393 | 47·0 | 42·2 | 4·8 | 36·8 |
| | 7 54 0 ,, | 28·46 | 1,365 | 48·0 | 42·5 | 5·5 | 36·4 |
| (3) | 7 59 0 ,, | 28·51 | 1,318 | 48·0 | 42·5 | 5·5 | 36·4 |
| (4) | 7 59 30 ,, | ..... | ..... | 48·2 | 43·2 | 5·0 | 37·7 |
| (5) | 8 0 0 ,, | 28·81 | 1,031 | 48·2 | 43·2 | 5·0 | 37·7 |
| | 8 1 0 ,, | 28·88 | 960 | 48·3 | 43·3 | 5·0 | 37·8 |
| (6) | 8 3 0 ,, | 28·91 | 939 | 48·3 | 43·3 | 5·0 | 37·8 |
| | 8 4 0 ,, | 29·01 | 842 | 49·0 | 44·5 | 4·5 | 40·6 |
| (7) | 8 5 0 ,, | 29·06 | 801 | 49·5 | 44·5 | 5·0 | 39·1 |
| (8) | 8 6 0 ,, | 29·21 | 663 | 51·2 | 46·0 | 5·2 | 40·6 |
| | 8 7 0 ,, | 29·22 | 654 | 51·2 | 46·0 | 5·2 | 40·6 |
| (9) | 8 8 0 ,, | 29·22 | 654 | 51·2 | 46·0 | 5·2 | 40·6 |
| | 8 9 0 ,, | 29·41 | 479 | 54·0 | 47·8 | 6·2 | 41·7 |
| | 8 10 0 ,, | 28·74 | 1,110 | 52·0 | 46·5 | 5·5 | 40·9 |
| | 8 11 0 ,, | 28·46 | 1,379 | 51·0 | 46·2 | 4·8 | 41·2 |
| | 8 12 0 ,, | 28·26 | 1,571 | 50·5 | 45·5 | 5·0 | 40·2 |
| | 8 13 0 ,, | 27·88 | 1,958 | 49·1 | 44·1 | 5·0 | 38·7 |
| | 8 14 0 ,, | 27·46 | 2,362 | 48·2 | 43·7 | 4·5 | 38·8 |
| | 8 15 0 ,, | 27·01 | 2,795 | 47·0 | 43·0 | 4·0 | 38·5 |
| | 8 15 30 ,, | 26·66 | 3,152 | 44·2 | 41·8 | 2·4 | 39·0 |
| | 8 16 0 ,, | 26·28 | 3,540 | 43·5 | 40·8 | 2·7 | 37·6 |
| | 8 16 30 ,, | 26·06 | 3,761 | 42·2 | 40·5 | 1·7 | 38·4 |
| | 8 17 0 ,, | 25·87 | 3,952 | 41·0 | 40·9 | 0·1 | 40·8 |
| | 8 17 30 ,, | 25·64 | 4,197 | 39·8 | 38·2 | 1·6 | 36·1 |
| | 8 17 45 ,, | 25·45 | 4,388 | 39·1 | 38·0 | 1·1 | 36·6 |
| | 8 18 0 ,, | 25·27 | 4,579 | 38·9 | 38·2 | 0·7 | 37·3 |
| | 8 18 15 ,, | 25·08 | 4,778 | 38·9 | 38·5 | 0·4 | 38·0 |
| | 8 18 30 ,, | 24·88 | 4,990 | 38·9 | 38·5 | 0·4 | 38·0 |
| | 8 18 45 ,, | 24·74 | 5,143 | 38·9 | 38·5 | 0·4 | 38·0 |
| (10) | 8 19 0 ,, | 24·56 | 5,339 | 38·9 | 38·5 | 0·4 | 38·0 |
| | 8 19 15 ,, | 24·38 | 5,533 | 38·5 | 38·4 | 0·1 | 38·3 |
| | 8 19 30 ,, | 24·28 | 5,642 | 38·0 | 38·0 | 0·0 | 38·0 |
| | 8 19 45 ,, | 23·96 | 5,979 | 34·5 | 34·2 | 0·3 | 33·7 |
| (11) | 8 20 0 ,, | 23·76 | 6,197 | 33·5 | 33·3 | 0·2 | 33·0 |
| | 8 20 15 ,, | 23·66 | 6,317 | 33·6 | 33·4 | 0·2 | 33·2 |
| | 8 20 30 ,, | 23·64 | 6,341 | 34·0 | 34·0 | 0·0 | 34·0 |
| | 8 20 45 ,, | 23·64 | 6,341 | 34·5 | 34·5 | 0·0 | 34·5 |
| | 8 21 0 ,, | 23·64 | 6,341 | 34·6 | 34·5 | 0·1 | 34·4 |
| | 8 21 15 ,, | 23·61 | 6,377 | 35·0 | 34·9 | 0·1 | 34·8 |
| | 8 21 30 ,, | 23·58 | 6,413 | 35·1 | 34·9 | 0·2 | 34·6 |
| | 8 21 45 ,, | 23·63 | 6,356 | 35·2 | 35·0 | 0·2 | 34·5 |
| (12) | 8 22 15 ,, | 23·77 | 6,198 | 35·9 | 35·3 | 0·6 | 34·4 |
| | 8 22 30 ,, | 23·78 | 6,186 | 35·9 | 35·3 | 0·6 | 34·4 |
| | 8 22 45 ,, | 23·91 | 6,039 | 35·9 | 35·3 | 0·6 | 34·4 |
| | 8 23 0 ,, | 23·96 | 5,982 | 35·9 | 35·3 | 0·6 | 34·4 |
| | 8 23 15 ,, | 24·04 | 5,892 | 35·5 | 35·2 | 0·3 | 34·7 |
| | 1. | 2. | 3. | 4. | 5. | 6. | 7. |

(1) Appearance of May trees very peculiar. (2) The parachute seems to skim over the earth. (3) Parachute reached the earth. (4) Can hear the quacking of ducks. (5) The radiation thermometer reads 44°. (6) Close to the town of Guildford, which is a little west of us. (7) Passing over high land; Box Hill range. (8) Sun setting. (9) Sucked down very remarkably on going over the hill; two bags of sand required to counteract the effect. (10) Opened the valve a little; the first time since leaving Windsor. (11) Sensibly damp and cold. (12) Mist over the earth; cannot see far.

TABLE I. c (*continued*).

| References to Notes. | Time. | Aneroid Barometer. | Height above sea-level. | Dry and Wet Thermometers (free). | | | |
|---|---|---|---|---|---|---|---|
| | | | | Dry. | Wet. | Diff. | Dew-point. |
| | h m s | in. | feet. | ° | ° | ° | ° |
| | 8 23 30 p.m. | 24·04 | 5,892 | 35·0 | 34·2 | 0·8 | 32·9 |
| | 8 23 45 „ | 23·94 | 6,005 | 35·5 | 34·6 | 0·9 | 33·2 |
| | 8 24 0 „ | 23·88 | 6,073 | 36·0 | 34·5 | 1·5 | 32·3 |
| | 8 25 0 „ | 23·86 | 6,096 | 36·0 | 34·3 | 1·7 | 32·7 |
| | 8 26 0 „ | 23·86 | 6,096 | 36·2 | 34·2 | 2·0 | 31·2 |
| | 8 27 0 „ | 23·88 | 6,073 | 35·9 | 34·1 | 1·8 | 30·1 |
| | 8 28 0 „ | 23·78 | 6,186 | 35·6 | 33·9 | 1·7 | 31·3 |
| | 8 29 0 „ | 23·84 | 6,118 | 35·9 | 33·9 | 2·0 | 30·9 |
| | 8 30 0 „ | 23·88 | 6,073 | 36·0 | 33·8 | 2·2 | 30·5 |
| | 8 31 0 „ | 24·06 | 5,873 | 35·6 | 33·5 | 2·1 | 30·2 |
| | 8 32 0 „ | 24·19 | 5,733 | 35·7 | 33·5 | 2·2 | 30·1 |
| | 8 33 0 „ | 24·38 | 5,528 | 36·5 | 34·2 | 2·3 | 30·9 |
| | 8 34 0 „ | 24·51 | 5,388 | 36·8 | 34·3 | 2·5 | 30·8 |
| | 8 35 0 „ | 24·86 | 5,010 | 36·8 | 34·4 | 2·4 | 31·0 |
| (1) | 8 36 0 „ | 25·11 | 4,740 | 37·2 | 35·1 | 2·1 | 32·2 |
| | 8 37 0 „ | 25·46 | 4,362 | 37·2 | 35·8 | 1·4 | 33·9 |
| | 8 38 0 „ | 25·78 | 4,036 | 38·7 | 38·1 | 0·6 | 37·3 |
| | 8 39 0 „ | 26·01 | 3,801 | 39·0 | 37·1 | 1·9 | 34·6 |
| | 8 40 0 „ | 26·16 | 3,646 | 39·3 | 37·2 | 2·1 | 34·4 |
| | 8 40 30 „ | 26·21 | 3,595 | 40·0 | 37·8 | 2·2 | 34·9 |
| | 8 41 0 „ | 26·41 | 3,391 | 40·7 | 37·8 | 2·9 | 34·1 |
| | 8 41 30 „ | 26·44 | 3,361 | 41·0 | 37·9 | 3·1 | 34·0 |
| | 8 42 0 „ | 26·48 | 3,321 | 41·0 | 38·0 | 3·0 | 34·2 |
| | 8 43 0 „ | 26·76 | 3,041 | 43·5 | 40·5 | 3·0 | 37·0 |
| | 8 43 30 „ | 26·81 | 2,991 | 43·7 | 40·5 | 3·2 | 36·7 |
| (2) | 8 44 0 „ | 26·83 | 2,971 | 43·6 | 40·5 | 3·1 | 36·8 |
| | 8 45 0 „ | 26·98 | 2,823 | 44·0 | 40·7 | 3·3 | 36·8 |
| | 8 46 0 „ | 27·38 | 2,427 | 44·5 | 41·0 | 3·5 | 36·9 |
| (3) | 8 46 30 „ | 27·71 | 2,104 | 45·0 | 41·2 | 3·8 | 36·6 |
| | 8 47 0 „ | 28·01 | 1,810 | 46·5 | 42·1 | 4·4 | 37·1 |
| | 8 48 0 „ | 28·08 | 1,743 | 47·0 | 43·0 | 4·0 | 38·5 |
| (4) | 8 48 30 „ | 28·44 | 1,397 | 48·2 | | | |
| | 8 49 0 „ | 28·68 | 1,186 | 49·3 | 45·1 | 4·2 | 40·6 |
| | 8 50 0 „ | 28·91 | 967 | 52·5 | 47·8 | 4·7 | 43·0 |
| | 8 51 0 „ | 29·01 | 872 | 53·0 | 47·4 | 5·6 | 41·8 |
| | 8 52 0 „ | 29·08 | 802 | 53·2 | 47·4 | 5·8 | 41·6 |
| (5) | 8 53 0 „ | 29·16 | 722 | 53·7 | 48·2 | 5·5 | 42·8 |
| | 8 54 0 „ | 29·16 | 722 | 53·7 | 49·9 | 3·8 | 46·2 |
| | 8 55 0 „ | 29·16 | 722 | 53·7 | 49·9 | 3·8 | 46·2 |
| | 8 56 0 „ | 29·16 | 722 | 53·7 | 49·9 | 3·8 | 46·2 |
| | 8 57 0 „ | 29·16 | 722 | 53·7 | 49·9 | 3·8 | 46·2 |
| | 8 58 0 „ | 29·16 | 722 | 53·9 | 49·7 | 4·2 | 45·5 |
| | 8 59 0 „ | 29·16 | 722 | 54·0 | | | |
| | 9 0 0 „ | 29·16 | 722 | 54·0 | 49·3 | 4·7 | 44·7 |
| | 9 1 0 „ | 29·28 | 608 | 53·8 | 49·0 | 4·8 | 44·3 |
| | 9 2 0 „ | 29·20 | 684 | 53·5 | | | |
| | 9 3 0 „ | 29·10 | 779 | 53·7 | 47·5 | 6·2 | 41·3 |
| (6) | 9 4 0 „ | 29·01 | 865 | 54·0 | 46·2 | 7·8 | 38·6 |
| (7) | 9 10 0 „ | 29·16 | 722 | 53·8 | 45·0 | 8·8 | 36·4 |
| | 9 12 0 „ | 28·91 | 961 | 54·0 | 45·5 | 8·5 | 37·2 |
| | 9 13 0 „ | 29·16 | 722 | 53·8 | 45·4 | 8·4 | 37·1 |
| | 9 14 0 „ | 29·26 | 631 | 53·0 | 45·4 | 7·6 | 37·3 |
| | 9 15 0 „ | 29·31 | 585 | 52·7 | 45·3 | 7·4 | 37·9 |
| (8) | 9 25 0 „ | 29·55 | ground. | 50·2 | 45·0 | 5·2 | 39·5 |
| | 1. | 2. | 3. | 4. | 5. | 6. | 7. |

(1) Moon just peeped out of cloud. (2) Can hear a train to the left.
(3) Compelled to use the lamp. (4) Near Petworth.
(5) Extraordinary wooded country. (6) Began to pack up, being near the sea; land before us. (7) Sand thrown out. (8) Came to the ground at Mr. Ticknor's Farm, 5 miles south of Pulborough.

## § 4. Adopted Temperatures of the Air, the Wet-bulb, and the Dew-point in Three Balloon Ascents.

Table II. A.—Showing the adopted Reading of the Barometer, calculated Height above the Sea, Temperature of the Air, Temperature of the Wet-bulb Thermometer, and Temperature of the Dew-point, in the

Twenty-sixth Ascent,—October 2, 1865.

| Time of observation. P.M. | Reading of the Barom. reduced to 32° F. | Height above the level of the sea. | Temp. of the Air. | Temp. of the Wet-bulb. | Temp. of the Dew-point. | Time of observation. P.M. | Reading of the Barom. reduced to 32° F. | Height above the level of the sea. | Temp. of the Air. | Temp. of the Wet-bulb. | Temp. of the Dew-point. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| h m s | in. | feet. | ° | ° | ° | h m s | in. | feet. | ° | ° | ° |
| 1 45 0 | 30·00 | ..... | 61·2 | 58·4 | 55·9 | 7 4 0 | 28·84 | 1115 | 58·7 | 57·6 | 56·5 |
| 33 0 | 30·01 | ..... | 59·8 | 56·4 | 53·5 | 5 0 | 28·83 | 1124 | 58·7 | 57·6 | 56·5 |
| 45 0 | 30·01 | ..... | 58·8 | 57·0 | 55·4 | 7 0 | 28·84 | 1115 | 58·6 | 57·6 | 56·7 |
| 55 0 | 30·01 | ..... | 57·8 | 55·9 | 54·2 | 9 0 | 28·84 | 1115 | 58·6 | 57·4 | 56·3 |
| 15 0 | 30·01 | ..... | 57·0 | | | 11 0 | 29·04 | 925 | 58·6 | 57·4 | 56·3 |
| 16 0 | 30·01 | ..... | 57·0 | | | 12 0 | 28·99 | 970 | 58·7 | | |
| 17 0 | 30·01 | ..... | 56·5 | | | 15 0 | 29·04 | 925 | 58·2 | 56·8 | 55·5 |
| 20 0 | ..... | ..... | 56·0 | 55·0 | 54·0 | 16 0 | 29·14 | 835 | 57·2 | 55·8 | 54·5 |
| 22 0 | 29·90 | 107 | 56+ | | | 17 0 | 29·19 | 790 | 57·3 | 55·8 | 54·3 |
| 25 0 | 28·99 | 967 | 57+ | | | 18 0 | 29·34 | 655 | 57·5 | 56·2 | 55·0 |
| 26 30 | 28·81 | 1139 | 58·2 | | | 19 0 | 29·04 | 925 | 58·2 | 55·6 | 53·2 |
| 28 0 | 28·68 | 1266 | 58·7 | 57·2 | 55·9 | 21 0 | 29·09 | 880 | 58·8 | 56·9 | 55·2 |
| 29 0 | 28·64 | 1302 | 58·9 | 57·5 | 56·2 | 22 0 | 29·24 | 745 | 58·2 | 56·8 | 55·5 |
| 30 0 | 28·94 | 1011 | 58·5 | | | 24 0 | 29·16 | 817 | | | |
| 31 0 | 28·94 | 1011 | 58·2 | 56·5 | 55·0 | 27 0 | 29·16 | 817 | 58·5 | 56·5 | 54·7 |
| 32 0 | ..... | ..... | 58·0 | 56·5 | 55·2 | 30 0 | 29·16 | 817 | 58·5 | 57·0 | 55·6 |
| 33 0 | 29·24 | 727 | 57·8 | 57·0 | 56·3 | 32 0 | 29·34 | 637 | 58·0 | 56·7 | 55·5 |
| 35 0 | 28·99 | 967 | 57·8 | 57·0 | 56·3 | 35 0 | 29·44 | 537 | 57·6 | 56·1 | 54·8 |
| 36 0 | 28·69 | 1255 | 58·2 | 57·2 | 56·3 | 37 0 | 29·24 | 737 | 58·0 | 56·5 | 55·2 |
| 37 0 | 28·62 | 1323 | 57·8 | 57·2 | 56·7 | 39 0 | 29·03 | 947 | 58·6 | | |
| 38 0 | 28·64 | 1304 | 58·0 | 57·2 | 56·5 | 44 0 | 29·55 | 519 | 57·2 | 56·2 | 55·3 |
| 40 0 | 28·62 | 1322 | 58·0 | 57·3 | 56·6 | 46 0 | 29·44 | 618 | 57·2 | 55·0 | 52·9 |
| 41 0 | 28·53 | 1409 | 58·0 | 57·3 | 56·6 | 48 0 | 29·39 | 663 | 58·0 | 55·8 | 54·7 |
| 42 0 | 28·56 | 1380 | 57·8 | 57·2 | 56·7 | 50 0 | 29·16 | 802 | 58·0 | 55·9 | 54·9 |
| 43 0 | 28·54 | 1399 | 58·2 | 57·5 | 56·9 | 52 0 | 29·06 | 898 | 58·7 | | |
| 45 0 | 28·56 | 1380 | 58·2 | 57·5 | 56·9 | 55 0 | 28·94 | 1029 | 58·4 | 56·0 | 53·8 |
| 46 0 | 28·61 | 1331 | 58·2 | 57·3 | 54·6 | 58 0 | 28·94 | 1029 | 58·5 | | |
| 48 30 | 28·64 | 1302 | 58·2 | | | 8 0 0 | 29·24 | 751 | 56·8 | 54·6 | 53·5 |
| 50 0 | 28·69 | 1254 | 58·0 | 57·4 | 56·9 | 2 0 | 29·44 | 561 | 57·0 | | |
| 52 0 | 28·64 | 1302 | 58·0 | 57·4 | 56·9 | 4 0 | 29·36 | 637 | 57·2 | 55·5 | 54·0 |
| 53 0 | 28·64 | 1302 | 58·0 | 57·5 | 57·0 | 10 0 | 29·14 | 846 | 57·7 | | |
| 54 0 | 28·38 | 1552 | 58·9 | 57·9 | 57·0 | 12 0 | 29·36 | 637 | 56·9 | 54·5 | 52·3 |
| 55 0 | 28·14 | 1785 | 59·0 | 58·2 | 57·5 | 15 0 | 29·09 | 890 | 57·2 | 55·0 | 53·0 |
| 56 0 | 27·97 | 1949 | 59·6 | 58·6 | 57·8 | 16 0 | 29·24 | 756 | 57·5 | 54·9 | 52·4 |
| 58 0 | 28·45 | 1488 | 59·0 | 58·1 | 57·3 | 18 0 | 29·61 | 403 | 57·3 | 56·0 | 54·8 |
| 7 0 0 | 28·76 | 1191 | 59·3 | 58·1 | 57·1 | 20 0 | ..... | ground. | 56·0 | 55·6 | 55·2 |
| 2 0 | 28·66 | 1286 | 58·8 | 57·2 | 55·8 | | | | | | |

TWENTY-SEVENTH ASCENT.—December 2, 1865.

| Time of observation. P.M. | Reading of the Barom. reduced to 32° F. | Height above the level of the sea. | Temp. of the Air. | Temp. of the Wet-bulb. | Temp. of the Dew-point. | Time of observation. P.M. | Reading of the Barom. reduced to 32° F. | Height above the level of the sea. | Temp. of the Air. | Temp. of the Wet-bulb. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| h m s | in. | feet. | ° | ° | ° | h m s | in. | feet. | ° | ° | ° |
| 5 0 0 | 29·68 | on the ground. | 38·8 | 38·0 | 37·0 | 5 59 0 | 26·98 | 2589 | 32·7 | 32·5 | 31 |
| 8 0 | 29·68 | | 39·0 | 38·1 | 36·9 | 6 0 0 | 27·03 | 2541 | 32·7 | 32·5 | 31 |
| 9 0 | 29·68 | | 39·0 | 38·0 | 36·7 | 1 0 | 27·08 | 2492 | 33·0 | 33·0 | 33 |
| 11 0 | 29·68 | | 39·0 | 38·0 | 36·7 | 2 0 | 26·83 | 2736 | 33·0 | 33·0 | 33 |
| 14 0 | 29·68 | | 38·5 | 38·0 | 37·4 | 3 0 | 26·65 | 2909 | 33·0 | 33·0 | 33 |
| 15 0 | 29·68 | | 38·3 | 38·0 | 37·6 | 4 0 | 26·63 | 2929 | 33·0 | 32·8 | 32 |
| 16 0 | 29·38 | 320 | 36·6 | 36·2 | 35·7 | 5 0 | 26·61 | 2949 | 33·1 | 32·9 | 32 |
| 17 0 | 28·23 | 1410 | 36·2 | 36·0 | 35·7 | 6 0 | 26·58 | 2978 | 33·0 | 32·7 | 32 |
| 18 0 | 28·15 | 1485 | 36·2 | 36·0 | 35·7 | 6 30 | 26·53 | 3032 | 33·1 | 32·6 | 31 |
| 19 0 | 28·13 | 1504 | 36·2 | 36·2 | 36·2 | 7 0 | 26·53 | 3032 | 33·3 | 32·9 | 32 |
| 20 0 | 28·13 | 1504 | 36·2 | 36·0 | 35·7 | 8 0 | 26·63 | 2934 | 33·3 | | |
| 21 0 | 28·03 | 1598 | 36·3 | 36·2 | 36·0 | 8 30 | 26·38 | 3179 | 34·0 | 31·7 | 27 |
| 22 0 | 28·33 | 1316 | 36·3 | 36·2 | 36·0 | 9 0 | 26·33 | 3228 | 32·4 | 32·0 | 31 |
| 24 0 | 28·38 | 1269 | 36·2 | 35·8 | 35·3 | 10 0 | 26·33 | 3228 | 32·0 | 31·7 | 31 |
| 25 0 | 28·38 | 1269 | 36·5 | | | 12 0 | 26·43 | 3129 | 32·7 | 32·2 | 31 |
| 26 0 | 28·28 | 1363 | 36·6 | 36·5 | 36·4 | 13 0 | 26·58 | 2980 | 32·8 | 32·2 | 31 |
| 27 0 | 28·23 | 1410 | 36·7 | 36·6 | 36·5 | 14 0 | 26·61 | 2950 | 33·3 | 33·0 | 32 |
| 29 0 | 27·98 | 1643 | 36·3 | 36·0 | 36·5 | 15 0 | 26·65 | 2910 | 33·5 | 32·3 | 32 |
| 30 0 | 27·93 | 1692 | 36·4 | 35·9 | 35·2 | 16 0 | 26·88 | 2680 | 33·4 | 32·7 | 32 |
| 31 0 | 27·98 | 1642 | 37·2 | 37·0 | 36·7 | 17 0 | 27·13 | 2443 | 34·0 | 33·5 | 33 |
| 32 0 | 28·00 | 1625 | 36·6 | 37·0 | | 18 0 | 26·68 | 2883 | 32·8 | 32·3 | 32 |
| 32 + | 28·08 | 1548 | | | | 22 0 | 26·08 | 3477 | 29·5 | 27·8 | 25 |
| 33 0 | 28·01 | 1615 | 36·6 | 36·6 | 36·6 | 23 0 | 26·01 | 3546 | 29·4 | 27·2 | 19 |
| 34 0 | 27·93 | 1692 | 36·7 | 36·6 | 36·5 | 24 0 | 25·91 | 3646 | 29·5 | 27·3 | 20 |
| 35 0 | 27·93 | 1692 | 36·6 | 36·6 | 36·6 | 25 0 | 25·88 | 3675 | 29·6 | 27·4 | 20 |
| 36 0 | 27·68 | 1930 | 36·3 | 36·2 | 36·0 | 26 0 | 25·88 | 3675 | 29·6 | 27·5 | 20 |
| 37 0 | 27·58 | 2025 | 36·2 | 36·0 | 35·7 | 27 0 | 25·97 | 3585 | 30·0 | 29·5 | 27 |
| 38 0 | 27·52 | 2083 | 36·0 | 35·8 | 35·5 | 28 0 | 26·13 | 3425 | 31·1 | 30·0 | 27 |
| 38 + | 27·48 | 2121 | 36·5 | 36·3 | 36·0 | 29 0 | 26·23 | 3325 | 31·2 | 30·0 | 28 |
| 39 0 | 27·83 | 1788 | 37·0 | 36·8 | 36·6 | 30 0 | 26·35 | 3206 | 31·2 | 30·0 | 28 |
| 40 0 | 27·88 | 1741 | 37·3 | 37·0 | 36·6 | 31 0 | 26·35 | 3206 | 31·2 | 29·9 | 28 |
| 41 0 | 27·93 | 1692 | 37·6 | 37·2 | 36·7 | 32 0 | 26·13 | 3426 | 30·9 | 29·0 | 26 |
| 44 0 | 27·93 | 1692 | 37·5 | 37·2 | 36·8 | 33 0 | 25·95 | 3606 | 29·2 | 28·1 | 24 |
| 45 0 | 27·73 | 1882 | 37·2 | 37·2 | 37·2 | 34 0 | 25·73 | 3826 | 27·8 | 26·2 | 19 |
| 46 0 | 27·53 | 2072 | 35·0 | 35·2 | | 35 0 | 25·71 | 3846 | 27·8 | 26·2 | 19 |
| 47 0 | 27·28 | 2323 | 34·2 | 34·0 | 33·7 | 36 0 | 25·55 | 4003 | 27·5 | 26·2 | 20 |
| 47 + | 27·08 | 2522 | 34·2 | 34·2 | 34·2 | 38 0 | 25·43 | 4126 | 27·2 | 26·5 | 23 |
| 48 0 | 26·98 | 2601 | 34·0 | 34·0 | 34·0 | 39 0 | 25·15 | 4406 | 27·2 | 26·2 | 21 |
| 49 0 | 26·98 | 2601 | 34·0 | 34·0 | 34·0 | 39 30 | 24·93 | 4628 | 27·2 | 26·2 | 21 |
| 50 0 | 27·13 | 2457 | 34·2 | 34·2 | 34·2 | 40 0 | 25·13 | 4428 | 27·2 | 26·0 | 20 |
| 50 30 | 27·44 | 2157 | 34·8 | 34·2 | 34·2 | 41 0 | 25·28 | 4278 | 27·7 | 27·2 | 25 |
| 51 0 | 27·51 | 2088 | 35·0 | 34·9 | 34·8 | 42 0 | 25·88 | 3678 | 29·9 | 28·5 | 24 |
| 52 0 | 27·53 | 2068 | 34·8 | 34·0 | 32·7 | 43 0 | 26·01 | 3542 | 30·0 | 29·0 | 25 |
| 53 0 | 27·53 | 2068 | 34·8 | 34·6 | 34·3 | 44 0 | 26·08 | 3478 | 30·5 | 29·6 | 27 |
| 54 0 | 27·48 | 2316 | 34·5 | 34·3 | 34·0 | 45 0 | 26·43 | 3128 | 31·0 | 30·3 | 28 |
| 56 30 | 27·01 | 2560 | 32·8 | 33·0 | | 46 0 | 26·93 | 2628 | 32·0 | 31·5 | 30 |
| 58 0 | 26·98 | 2589 | 32·7 | 32·6 | 32·4 | 47 0 | 27·13 | 2428 | 32·5 | 32·0 | 31 |

## TWENTY-EIGHTH ASCENT.—May 29, 1866.

| Time of observation. P.M. | Reading of the Barom. reduced to 32° F. | Height above the level of the sea. | Temp. of the Air. | Temp. of the Wet-bulb. | Temp. of the Dew-point. | Time of observation. P.M. | Reading of the Barom. reduced to 32° F. | Height above the level of the sea. | Temp. of the Air. | Temp. of the Wet-bulb. | Temp. of the Dew-point. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| h m s | in. | feet. | ° | ° | ° | h m s | in. | feet. | ° | ° | ° |
| 12 0 | 29·88 | ground | 58·0 | 55·0 | 52·3 | 7 20 0 | 23·76 | 6162 | 30·5 | 28·5 | 22·8 |
| | | | | | | 21 0 | 23·86 | 6053 | 31·0 | 28·0 | 19·8 |
| 14 30 | 29·31 | 562 | 57·2 | 55·1 | 53·2 | 22 0 | 23·91 | 5998 | 31·5 | 28·7 | 21·8 |
| 15 0 | 28·56 | 1247 | 55·2 | 53·1 | 51·1 | 23 0 | 23·98 | 5922 | 32·0 | 29·5 | 23·7 |
| 16 0 | 28·46 | 1340 | 54·7 | 52·5 | 50·3 | 24 0 | 23·88 | 6031 | 31·8 | 29·2 | 23·0 |
| 17 0 | ..... | ..... | 53·5 | 51·0 | 48·5 | 26 0 | 24·11 | 5790 | 31·8 | 30·0 | 25·8 |
| 17 30 | 28·01 | 1782 | 52·5 | 48·1 | 43·6 | 27 0 | 24·26 | 5617 | 32·2 | 31·5 | 30·1 |
| 18 0 | 27·86 | 1929 | 52·5 | 47·1 | 41·6 | 28 0 | 24·41 | 5454 | 33·0 | 31·2 | 27·6 |
| 19 0 | 27·76 | 2027 | 52·2 | 46·5 | 40·7 | 29 0 | 24·51 | 5350 | 33·0 | 31·2 | 27·6 |
| 20 0 | 27·76 | 2027 | 52·8 | 47·2 | 41·5 | 30 0 | 24·66 | 5197 | 33·2 | 31·0 | 26·7 |
| 21 0 | 27·88 | 1908 | 52·2 | 47·5 | 42·7 | 31 0 | 24·76 | 5078 | 34·0 | 31·2 | 26·2 |
| 21 30 | 27·96 | 1829 | 53·0 | 47·0 | 41·0 | 32 0 | 24·81 | 5025 | 34·5 | 31·8 | 27·3 |
| 21 45 | 27·96 | 1829 | 52·7 | 47·0 | 41·2 | 33 0 | 24·91 | 4919 | 34·5 | 32·2 | 28·3 |
| 22 0 | 27·77 | 2017 | 52·5 | 47·3 | 42·0 | 34 0 | 25·28 | 4526 | 35·5 | 33·1 | 29·4 |
| 23 0 | 27·56 | 2223 | 50·2 | 45·0 | 39·5 | 35 0 | 25·37 | 4431 | 36·0 | 34·2 | 31·5 |
| 24 0 | 27·31 | 2469 | 49·2 | 44·8 | 40·0 | 37 0 | 25·58 | 4209 | 36·2 | 34·7 | 32·3 |
| | | | | | | 38 0 | 25·76 | 4019 | 36·2 | 35·0 | 33·2 |
| 27 0 | 27·06 | 2715 | 48·0 | 44·0 | 39·6 | 39 0 | 25·86 | 3918 | 37·1 | 35·8 | 34·0 |
| 31 30 | 26·81 | 2961 | 47·5 | 44·0 | 40·1 | 40 0 | 26·16 | 3615 | 38·0 | 36·5 | 34·5 |
| 32 0 | 26·81 | 2961 | 47·2 | 44·0 | 40·4 | 41 0 | 26·31 | 3463 | 38·9 | 36·7 | 33·8 |
| 33 0 | 26·68 | 3093 | 46·8 | 44·0 | 40·9 | 42 0 | 26·51 | 3261 | 39·2 | 37·0 | 34·1 |
| 36 0 | 26·61 | 3171 | 47·2 | 43·1 | 38·5 | 43 0 | 26·54 | 3230 | 40·5 | 37·5 | 33·7 |
| 37 0 | 26·51 | 3276 | 48·2 | 42·1 | 35·4 | 44 0 | 27·06 | 2716 | 41·1 | 37·8 | 33·7 |
| 39 0 | 26·37 | 3418 | 48·9 | 42·0 | 34·5 | 45 0 | 27·11 | 2669 | 41·1 | 38·0 | 34·1 |
| 40 0 | 26·31 | 3481 | 47·2 | 41·5 | 35·1 | 46 0 | 27·11 | 2669 | 42·0 | 38·5 | 34·2 |
| 43 0 | 26·01 | 3796 | 47·2 | 42·0 | 36·2 | 47 0 | 27·38 | 2407 | 43·5 | 40·0 | 35·8 |
| 45 0 | 25·96 | 3848 | 46·2 | 41·5 | 36·1 | 48 0 | 27·46 | 2329 | 44·0 | 40·2 | 35·7 |
| 46 0 | 25·91 | 3900 | 43·6 | 40·0 | 35·8 | 49 0 | 27·65 | 2742 | 44·9 | 40·3 | 34·9 |
| 47 0 | 25·78 | 4036 | 43·5 | 39·3 | 34·3 | 50 0 | 27·86 | 1937 | 44·9 | 40·5 | 35·4 |
| 48 0 | 25·56 | 4264 | 43·2 | 39·8 | 35·8 | 51 0 | 27·98 | 1821 | 45·0 | 40·9 | 36·2 |
| 51 0 | 25·51 | 4316 | 43·5 | 40·0 | 35·9 | 52 0 | 28·36 | 1457 | 46·2 | 42·0 | 37·2 |
| 52 0 | 25·46 | 4368 | 43·3 | 40·2 | 36·5 | 53 0 | 28·43 | 1393 | 47·0 | 42·2 | 36·8 |
| 53 0 | 25·38 | 4447 | 43·2 | 40·1 | 36·4 | 54 0 | 28·46 | 1365 | 48·0 | 42·5 | 36·4 |
| 54 0 | 25·26 | 4572 | 41·5 | 39·5 | 37·0 | 59 0 | 28·51 | 1318 | 48·0 | 42·5 | 36·4 |
| 55 0 | 25·16 | 4675 | 39·0 | 39·0 | 39·0 | 59 30 | ..... | ..... | 48·2 | 43·2 | 37·7 |
| 56 0 | 25·21 | 4623 | 39·5 | 39·0 | 38·4 | 8 0 0 | 28·81 | 1031 | 48·2 | 43·2 | 37·7 |
| 57 0 | 25·36 | 4467 | 40·5 | 38·7 | 35·3 | 1 0 | 28·88 | 960 | 48·3 | 43·3 | 37·8 |
| 58 0 | 25·41 | 4415 | 40·9 | 38·2 | 34·7 | 3 0 | 28·91 | 939 | 48·3 | 43·3 | 37·8 |
| 59 0 | 25·43 | 4394 | 41·0 | 38·1 | 34·4 | 4 0 | 29·01 | 847 | 49·0 | 44·5 | 40·6 |
| 7 0 0 | ..... | ..... | 39·2 | 37·5 | 35·3 | 5 0 | 29·06 | 801 | 49·5 | 44·5 | 39·1 |
| 1 0 | 24·91 | 4934 | 38·0 | 36·5 | 34·5 | 6 0 | 29·21 | 663 | 51·2 | 46·0 | 40·6 |
| 2 0 | 24·77 | 5078 | 37·2 | 36·1 | 34·6 | 7 0 | 29·22 | 654 | 51·2 | 46·0 | 40·6 |
| 3 0 | 24·67 | 5182 | 37·2 | 35·0 | 32·2 | 8 0 | 29·22 | 654 | 51·2 | 46·0 | 40·6 |
| 4 0 | 24·41 | 5469 | 35·0 | 34·5 | 33·7 | 9 0 | 29·41 | 479 | 54·0 | 47·8 | 41·7 |
| 6 0 | 24·40 | 5480 | 34·5 | 34·0 | 33·2 | 10 0 | 28·74 | 1110 | 52·0 | 46·5 | 40·9 |
| 7 0 | 24·16 | 5739 | 35·0 | 34·5 | 33·7 | 11 0 | 28·46 | 1379 | 51·0 | 46·2 | 41·2 |
| 8 0 | 24·16 | 5739 | 35·2 | 34·1 | 32·4 | 12 0 | 28·26 | 1571 | 50·5 | 45·5 | 40·2 |
| 9 0 | 24·14 | 5760 | 35·0 | 34·1 | 32·7 | 13 0 | 27·88 | 1958 | 49·1 | 44·1 | 38·7 |
| 10 0 | 24·14 | 5760 | 35·2 | 33·6 | 31·2 | 14 0 | 27·46 | 2362 | 48·2 | 43·7 | 38·8 |
| 11 0 | 24·21 | 5673 | 35·7 | 33·7 | 30·7 | 15 0 | 27·01 | 2795 | 47·0 | 43·0 | 38·5 |
| 12 0 | 24·36 | 5489 | 36·0 | 33·5 | 29·8 | 15 30 | 26·66 | 3152 | 44·2 | 41·8 | 39·0 |
| 14 0 | 24·11 | 5778 | 31·8 | 30·0 | 25·8 | 16 0 | 26·28 | 3540 | 43·5 | 40·8 | 37·6 |
| 15 0 | 24·06 | 5832 | 31·0 | 30·0 | 27·3 | 16 30 | 26·06 | 3761 | 42·2 | 40·5 | 38·4 |
| 16 0 | 23·91 | 5999 | 30·5 | 29·1 | 25·1 | 17 0 | 25·87 | 3952 | 41·0 | 40·9 | 40·8 |
| 17 0 | 23·76 | 6162 | 29·5 | 28·0 | 23·0 | 17 30 | 25·64 | 4197 | 39·8 | 38·2 | 36·1 |
| 18 0 | 23·61 | 6325 | 29·5 | 28·0 | 23·0 | 17 45 | 25·45 | 4388 | 39·1 | 38·0 | 36·6 |
| 19 0 | 23·66 | 6271 | 30·0 | 28·3 | 23·0 | 18 0 | 25·27 | 4579 | 38·9 | 38·2 | 37·3 |

TWENTY-EIGHTH ASCENT.—May 29, 1866 (*continued*).

| Time of observation. P.M. | Reading of the Barom. reduced to 32° F. | Height above the level of the sea. | Temp. of the Air. | Temp. of the Wet-bulb. | Temp. of the Dew-point. | Time of observation. P.M. | Reading of the Barom. reduced to 32° F. | Height above the level of the sea. | Temp. of the Air. | Temp. of the Wet-bulb. | Temp. of the Dew-point. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| h m s | in. | feet. | ° | ° | ° | h m s | in. | feet. | ° | ° | ° |
| 8 18 15 | 25·08 | 4778 | 38·9 | 38·5 | 38·0 | 8 39 0 | 26·01 | 3801 | 39·0 | 37·1 | 34·6 |
| 18 30 | 24·88 | 4990 | 38·9 | 38·5 | 38·0 | 40 0 | 26·16 | 3646 | 39·3 | 37·2 | 34·4 |
| 18 45 | 24·74 | 5143 | 38·9 | 38·5 | 38·0 | 40 30 | 26·21 | 3595 | 40·0 | 37·8 | 34·9 |
| 19 0 | 24·56 | 5339 | 38·9 | 38·5 | 38·0 | 41 0 | 26·41 | 3391 | 40·7 | 37·8 | 34·1 |
| 19 15 | 24·38 | 5533 | 38·5 | 38·4 | 38·3 | 41 30 | 26·44 | 3361 | 41·0 | 37·9 | 34·0 |
| 19 30 | 24·28 | 5642 | 38·0 | 38·3 | 38·0 | 42 0 | 26·48 | 3321 | 41·0 | 38·0 | 34·2 |
| 19 45 | 23·96 | 5979 | 34·5 | 34·2 | 33·7 | 43 0 | 26·76 | 3041 | 43·5 | 40·5 | 37·0 |
| 20 0 | 23·76 | 6197 | 33·5 | 33·3 | 33·0 | 43 30 | 26·81 | 2991 | 43·7 | 40·5 | 36·7 |
| 20 15 | 23·66 | 6317 | 33·6 | 33·4 | 33·2 | 44 0 | 26·83 | 2971 | 43·6 | 40·5 | 36·8 |
| 20 30 | 23·64 | 6341 | 34·0 | 34·0 | 34·0 | 45 0 | 26·98 | 2823 | 44·0 | 40·7 | 36·8 |
| 20 45 | 23·64 | 6341 | 34·5 | 34·5 | 34·5 | 46 0 | 27·38 | 2427 | 44·5 | 41·0 | 36·9 |
| 21 0 | 23·64 | 6341 | 34·6 | 34·5 | 34·4 | 46 30 | 27·71 | 2104 | 45·0 | 41·2 | 36·6 |
| 21 15 | 23·61 | 6377 | 35·0 | 34·9 | 34·8 | 47 0 | 28·01 | 1810 | 46·5 | 42·1 | 37·1 |
| 21 30 | 23·58 | 6413 | 35·1 | 34·9 | 34·6 | 48 0 | 28·08 | 1743 | 47·0 | 43·0 | 38·5 |
| 21 45 | 23·63 | 6356 | 35·2 | 35·0 | 34·5 | 48 30 | 28·44 | 1397 | 48·2 | | |
| 22 15 | 23·77 | 6198 | 35·9 | 35·3 | 34·4 | 49 0 | 28·68 | 1186 | 49·3 | 45·1 | 40·6 |
| 22 30 | 23·78 | 6186 | 35·9 | 35·3 | 34·4 | 50 0 | 28·91 | 967 | 52·5 | 47·8 | 43·0 |
| 22 45 | 23·91 | 6039 | 35·9 | 35·3 | 34·4 | 51 0 | 29·01 | 872 | 53·0 | 47·4 | 41·4 |
| 23 0 | 23·96 | 5982 | 35·9 | 35·3 | 34·4 | 52 0 | 29·08 | 802 | 53·2 | 47·4 | 41·6 |
| 23 15 | 24·04 | 5892 | 35·5 | 35·2 | 34·7 | 53 0 | 29·16 | 722 | 53·7 | 48·2 | 42·8 |
| 23 30 | 24·04 | 5892 | 35·0 | 34·2 | 32·9 | 54 0 | 29·16 | 722 | 53·7 | 49·9 | 46·2 |
| 23 45 | 23·94 | 6005 | 35·5 | 34·6 | 33·2 | 55 0 | 29·16 | 722 | 53·7 | 49·9 | 46·2 |
| 24 0 | 23·88 | 6073 | 36·0 | 34·5 | 32·3 | 56 0 | 29·16 | 722 | 53·7 | 49·9 | 46·2 |
| 25 0 | 23·86 | 6096 | 36·0 | 34·3 | 31·7 | 57 0 | 29·16 | 722 | 53·7 | 49·9 | 46·2 |
| 26 0 | 23·86 | 6096 | 36·2 | 34·2 | 31·2 | 58 0 | 29·16 | 722 | 53·9 | 49·7 | 45·5 |
| 27 0 | 23·88 | 6073 | 35·9 | 34·1 | 30·1 | 59 0 | 29·16 | 722 | 54·0 | | |
| 28 0 | 23·78 | 6186 | 35·6 | 33·9 | 31·3 | 9 0 0 | 29·16 | 722 | 54·0 | 49·3 | 44·7 |
| 29 0 | 23·84 | 6118 | 35·9 | 33·9 | 30·9 | 1 0 | 29·28 | 608 | 53·8 | 49·0 | 44·3 |
| 30 0 | 23·88 | 6073 | 36·0 | 33·8 | 30·5 | 2 0 | 29·20 | 684 | 53·5 | | |
| 31 0 | 24·06 | 5873 | 35·6 | 33·5 | 30·2 | 3 0 | 29·10 | 779 | 53·7 | 47·5 | 41·3 |
| 32 0 | 24·19 | 5733 | 35·7 | 33·5 | 30·1 | 4 0 | 29·01 | 865 | 54·0 | 46·2 | 38·6 |
| 33 0 | 24·38 | 5528 | 36·5 | 34·2 | 30·9 | 10 0 | 29·16 | 722 | 53·8 | 45·0 | 36·4 |
| 34 0 | 24·51 | 5388 | 36·8 | 34·3 | 30·8 | 12 0 | 28·91 | 961 | 54·0 | 45·5 | 37·2 |
| 35 0 | 24·86 | 5010 | 36·8 | 34·4 | 31·0 | 13 0 | 29·16 | 724 | 53·8 | 45·4 | 37·1 |
| 36 0 | 25·11 | 4740 | 37·2 | 35·1 | 32·2 | 14 0 | 29·26 | 631 | 53·0 | 45·4 | 37·8 |
| 37 0 | 25·46 | 4362 | 37·2 | 35·8 | 33·9 | 15 0 | 29·31 | 585 | 52·7 | 45·3 | 37·9 |
| 38 0 | 25·78 | 4036 | 38·7 | 38·1 | 37·3 | 25 0 | 29·55 | ground | 50·2 | 45·0 | 39·5 |

The readings of temperature in the preceding Tables were formed in small groups, including observations which had been taken in quick succession, or at about the same distance from the earth, or when the balloon had passed upwards and downwards through the same space within a few minutes; as, for example, on May 29, between $6^h\ 17^m$ and $6^h\ 22^m$

| | Height. feet. | Temperature. ° | Dew-point. ° |
|---|---|---|---|
| at 6 17 30 | 1782 | 52·5 | 43·6 |
| at 6 18 0 | 1929 | 52·5 | 41·6 |
| at 6 19 0 | 2027 | 52·2 | 40·7 |
| at 6 20 0 | 2027 | 52·8 | 41·5 |
| at 6 21 0 | 1908 | 52·2 | 42·7 |
| at 6 21 30 | 1829 | 53·0 | 41·0 |
| at 6 21 45 | 1829 | 52·7 | 41·2 |
| at 6 22 0 | 2017 | 52·5 | 42·0 |
| Mean..... | 1917 | 52·6 | 41·8 |

These mean values at the mean height were laid down on a diagram; all these points were joined, and a curved line was drawn through, or near them, so that the areas of the space between the original and the adopted lines on one side were equal to those of the spaces on the other side. The curve thus formed was assumed to be the curve of temperature freed from local disturbance, and that it was assumed that the deviations of the original curve indicated the places and the amount of disturbance.

The next step was reading from these curves the temperature at every 100 feet, and in this way the next Tables were formed.

The numbers in the first column show the height in feet, beginning from the ground and increasing upwards; the numbers in the second column show the interval of time in ascending to the highest point; the notes in the third column show the circumstances of the observations; the numbers in the fourth and fifth columns, the observations and the approximate true temperatures of the air, and those in the next column the difference between the two preceding columns, or the most probable effect of local disturbing causes.

The next group of columns are arranged similarly for the descent, and the other groups, on May 29, for the second ascent and second descent.

TABLE III.—Showing the Temperature of the Air, as read off the curve drawn through the observed temperatures, and as read off the curve of most probable normal temperatures, called adopted temperatures, and the calculated amount of disturbance from the assumed law of decrease of temperature.

TWENTY-SIXTH ASCENT.

| 1865. October 2nd. Height, in feet, above the mean level of the sea. | Temperature of the Air. Ascending. Between what times. | Circumstances. | Observed temp. | Adopted temp. | Calculated effect of disturbance. | Descending. Between what times. | Circumstances. | Observed temp. | Adopted temp. | Calculated effect of disturbance. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | ° | ° | ° | | | ° | ° | ° |
| 2000 | | | 59·8 | 59·8 | 0·0 | | | 59·8 | 59·8 | 0·0 |
| 1900 | | | 59·4 | 59·5 | − 0·1 | | | 59·6 | 59·6 | 0·0 |
| 1800 | | | 59·1 | 59·3 | − 0·2 | | | 59·4 | 59·5 | − 0·1 |
| 1700 | | | 59·0 | 59·1 | − 0·1 | | | 59·3 | 59·4 | − 0·1 |
| 1600 | | | 58·9 | 58·9 | 0·0 | | | 59·2 | 59·3 | − 0·1 |
| 1500 | | | 58·6 | 58·7 | − 0·1 | | | 59·0 | 59·2 | − 0·2 |
| 1400 | | | 58·1 | 58·5 | − 0·4 | | | 59·0 | 59·0 | 0·0 |
| 1300 | From 6h 20m p.m. to 6h 56m p.m. | Generally clear. | 58·2 | 58·3 | − 0·1 | From 6h 57m p.m. to 8h 20m p.m. | | 58·9 | 58·9 | 0·0 |
| 1200 | | | 58·3 | 58·1 | + 0·2 | | | 58·8 | 58·7 | + 0·1 |
| 1100 | | | 58·3 | 58·0 | + 0·3 | | Misty and very dark. | 58·7 | 58·6 | + 0·1 |
| 1000 | | | 58·2 | 57·7 | + 0·5 | | | 58·5 | 58·5 | 0·0 |
| 900 | | | 57·7 | 57·5 | + 0·2 | | | 58·3 | 58·3 | 0·0 |
| 800 | | | 57·4 | 57·4 | 0·0 | | | 57·8 | 58·2 | + 0·4 |
| 700 | | | 57·2 | 57·2 | 0·0 | | | 57·7 | 58·0 | + 0·3 |
| 600 | | | 57·0 | 57·0 | 0·0 | | | 57·4 | 57·8 | + 0·4 |
| 500 | | | 56·8 | 56·8 | 0·0 | | | 57·3 | 57·5 | + 0·2 |
| 400 | | | 56·7 | 56·7 | 0·0 | | | 57·3 | 57·3 | 0·0 |
| 300 | | | 56·5 | 56·5 | 0·0 | | | 57·0 | 57·0 | 0·0 |
| 200 | | | 56·3 | 56·3 | 0·0 | | | 56·7 | 56·7 | 0·0 |
| 100 | | | 56·1 | 56·1 | 0·0 | | | 56·4 | 56·4 | 0·0 |
| 0 | | | 56·0 | 55·8 | + 0·2 | | | 56·0 | 56·0 | 0·0 |

The temperature of the air was the lowest on the ground, and increased, with elevation, to the height of 2000 feet, the highest point attained; and on the descent it decreased with decrease of elevation, and was the lowest on reaching the ground.

TABLE III. (*continued*).

TWENTY-SEVENTH ASCENT.

| 1865. December 2. Height, in feet, above the mean level of the sea. | Temperature of the Air. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ascending. | | | | | Descending. | | | | |
| | Between what times. | Circumstances. | Observed temp. | Adopted temp. | Calculated effect of disturbance. | Between what times. | Circumstances. | Observed temp. | Adopted temp. | Calculated effect of disturbance. |
| | | | ° | ° | ° | | | ° | ° | ° |
| 4600 | | | 27·2 | 27·2 | 0·0 | | | 27·2 | 27·2 | 0·0 |
| 4500 | | | 27·2 | 27·2 | 0·0 | | | 27·2 | 27·4 | −0·2 |
| 4400 | | | 27·2 | 27·2 | 0·0 | | | 27·3 | 27·5 | −0·2 |
| 4300 | | | 27·2 | 27·2 | 0·0 | | | 27·6 | 27·7 | −0·1 |
| 4200 | | | 27·2 | 27·2 | 0·0 | | Very cloudy above. | 27·9 | 27·9 | 0·0 |
| 4100 | | | 27·3 | 27·3 | 0·0 | | | 28·2 | 28·2 | 0·0 |
| 4000 | | | 27·5 | 27·5 | 0·0 | | | 28·4 | 28·5 | −0·1 |
| 3900 | | | 27·7 | 27·8 | −0·1 | | | 28·6 | 28·7 | −0·1 |
| 3800 | | | 28·3 | 28·4 | −0·1 | | | 28·8 | 29·0 | −0·2 |
| 3700 | | | 29·0 | 29·0 | 0·0 | | | 29·3 | 29·3 | 0·0 |
| 3600 | | | 29·6 | 29·6 | 0·0 | | | 29·7 | 29·7 | 0·0 |
| 3500 | | Cold to sense. | 30·0 | 30·2 | −0·2 | | | 30·5 | 30·0 | +0·5 |
| 3400 | | | 30·8 | 30·8 | 0·0 | | | 30·6 | 30·3 | +0·3 |
| 3300 | | | 31·4 | 31·6 | −0·2 | | | 30·7 | 30·5 | +0·2 |
| 3200 | | | 32·3 | 32·2 | +0·1 | | | 30·9 | 30·9 | 0·0 |
| 3100 | | | 33·2 | 32·6 | +0·6 | | | 31·2 | 31·2 | 0·0 |
| 3000 | | | 33·1 | 32·8 | +0·3 | | | 31·4 | 31·4 | 0·0 |
| 2900 | | | 33·0 | 33·0 | 0·0 | | | 31·6 | 31·6 | 0·0 |
| 2800 | | | 33·0 | 33·2 | −0·2 | | | 31·8 | 31·8 | 0·0 |
| 2700 | | | 33·5 | 33·4 | +0·1 | | | 32·0 | 32·0 | 0·0 |
| 2600 | | | 34·0 | 33·5 | +0·5 | | | 32·3 | 32·3 | 0·0 |
| 2500 | | Clouds below. | 33·5 | 33·8 | −0·3 | | | 32·4 | 32·6 | −0·2 |
| 2400 | | | 34·0 | 34·1 | −0·1 | | Lamp extinguished. | | | |
| 2300 | | | 34·6 | 34·5 | +0·1 | | | | | |
| 2200 | | | 35·5 | 35·0 | +0·5 | | | | | |
| 2100 | | | 35·6 | 35·5 | +0·1 | | | | | |
| 2000 | | | 35·6 | 36·0 | −0·4 | | | | | |
| 1900 | | Very cloudy; nothing visible. | 37·0 | 36·9 | +0·1 | | | | | |
| 1800 | | | 37·2 | 37·2 | 0·0 | | | | | |
| 1700 | | | 36·9 | 36·9 | 0·0 | | | | | |
| 1600 | | | 36·5 | 36·6 | −0·1 | | | | | |
| 1500 | | | 36·2 | 36·4 | −0·2 | | | | | |
| 1400 | | | 36·1 | 36·2 | −0·1 | | | | | |
| 1300 | | | 36·2 | 36·2 | 0·0 | | | | | |
| 1200 | | | 36·2 | 36·2 | 0·0 | | | | | |
| 1100 | | | 36·2 | 36·2 | 0·0 | | | | | |
| 1000 | | | 36·3 | 36·3 | 0·0 | | | | | |
| 900 | | | 36·3 | 36·3 | 0·0 | | | | | |
| 800 | | | 36·4 | 36·4 | 0·0 | | | | | |
| 700 | | | 36·4 | 36·4 | 0·0 | | | | | |
| 600 | | | 36·5 | 36·5 | 0·0 | | | | | |
| 500 | | | 36·5 | 36·5 | 0·0 | | | | | |
| 400 | | | 36·5 | 36·5 | 0·0 | | | | | |
| 300 | | Misty all round. | 36·6 | 36·6 | 0·0 | | | | | |
| 200 | | | 37·1 | 37·1 | 0·0 | | | | | |
| 100 | | | 37·6 | 37·6 | 0·0 | | | | | |
| 0 | | | 38·5 | 38·5 | 0·0 | | | | | |

From 5h 15m p.m. to 6h 39m 30s p.m.

From 6h 39m 30s p.m. to 7h 10m p.m.

The temperature decreased from 38°·5 on the ground to 36°·6 at the height of 300 feet; was then very nearly stationary to the height of 1500 feet, de-

creasing to 36°·1 at this elevation; it then increased to 37°·2 at the height of 1800 feet, the sky being cloudy as seen from here, and the air was misty. In the next 100 feet the temperature declined 0°·2, and as much as 1°·4 in the succeeding 100 feet; the temperature then declined slowly to 34° at 2600 feet, the clouds being at a lower elevation: the decline of temperature continued to the height of 4000 feet, where it was 27½°, and there was very little change in the next 600 feet. On descending, the temperature slowly and steadily increased to 32°·4 at the height of 2500 feet, when the light was accidentally extinguished, and no more observations could be made.

TABLE III. (*continued*).

TWENTY-EIGHTH ASCENT.

| 1866. May 29. Height, in feet, above the mean level of the sea. | Temperature of the Air. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ascending. | | | | | Descending. | | | | |
| | Between what times. | Circumstances. | Observed temp. | Adopted temp. | Calculated effect of disturbance. | Between what times. | Circumstances. | Observed temp. | Adopted temp. | Calculated effect of disturbance. |
| | | | ° | ° | ° | | | ° | ° | ° |
| 6400 | | | | | | | | | | |
| 6300 | | | | | | | | | | |
| 6200 | | | 29·8 | 29·8 | 0·0 | | | 30·2 | 30·0 | +0·2 |
| 6100 | | | 30·2 | 30·6 | −0·4 | | | 30·8 | 30·5 | +0·3 |
| 6000 | | | 30·5 | 31·4 | −0·9 | | | 31·4 | 30·8 | +0·6 |
| 5900 | | | 30·8 | 32·3 | −1·5 | | | 31·6 | 31·3 | +0·3 |
| 5800 | | | 31·4 | 33·0 | −1·6 | | | 31·8 | 31·6 | +0·2 |
| 5700 | | | 35·2 | 34·0 | +1·2 | | | 32·0 | 32·0 | 0·0 |
| 5600 | | | 35·2 | 34·5 | +0·7 | | | 32·4 | 32·4 | 0·0 |
| 5500 | | | 35·2 | 35·0 | +0·2 | | | 32·6 | 32·6 | 0·0 |
| 5400 | | | 35·6 | 35·6 | 0·0 | | | 33·0 | 33·0 | 0·0 |
| 5300 | | | 36·3 | 36·3 | 0·0 | | | 33·4 | 33·4 | 0·0 |
| 5200 | | | 36·9 | 36·9 | 0·0 | | | 33·7 | 33·7 | 0·0 |
| 5100 | | | 37·5 | 37·6 | −0·1 | | | 34·0 | 34·0 | 0·0 |
| 5000 | | | 38·0 | 38·1 | −0·1 | | | 34·3 | 34·3 | 0·0 |
| 4900 | | | 38·5 | 38·7 | −0·2 | | | 34·6 | 34·6 | 0·0 |
| 4800 | | | 39·0 | 39·3 | −0·3 | | | 34·9 | 34·9 | 0·0 |
| 4700 | | | 39·5 | 39·9 | −0·4 | | | 35·2 | 35·2 | 0·0 |
| 4600 | | | 40·2 | 40·6 | −0·4 | | | 35·5 | 35·5 | 0·0 |
| 4500 | | | 41·2 | 41·2 | 0·0 | | | 35·7 | 35·7 | 0·0 |
| 4400 | | Misty. | 42·0 | 41·8 | +0·2 | | | 36·0 | 36·0 | 0·0 |
| 4300 | | | 42·6 | 42·3 | +0·3 | | | 36·2 | 36·4 | −0·2 |
| 4200 | | | 43·3 | 43·0 | +0·3 | | | 36·3 | 36·7 | −0·4 |
| 4100 | | | 43·7 | 43·5 | +0·2 | | | 36·5 | 37·0 | −0·5 |
| 4000 | | | 44·5 | 44·0 | +0·5 | | | 36·7 | 37·3 | −0·6 |
| 3900 | | | 45·2 | 44·5 | +0·7 | | | 37·1 | 37·7 | −0·6 |
| 3800 | | | 46·6 | 45·0 | +1·6 | | | 37·4 | 37·9 | −0·5 |
| 3700 | | | 46·8 | 45·6 | +1·2 | | | 37·8 | 38·3 | −0·5 |
| 3600 | | | 47·0 | 46·0 | +1·0 | | | 38·2 | 38·6 | −0·4 |
| 3500 | | Blue sky above. Sun warm to sense. | 47·2 | 46·5 | +0·7 | | | 38·5 | 38·9 | −0·4 |
| 3400 | | | 48·7 | 46·9 | +1·8 | | | 39·1 | 39·3 | −0·2 |
| 3300 | | | 48·3 | 47·3 | +1·0 | | | 39·6 | 39·5 | +0·1 |
| 3200 | | | 47·5 | 47·5 | 0·0 | | | 40·0 | 39·9 | +0·1 |
| 3100 | | | 46·7 | 48·0 | −1·3 | | | 40·3 | 40·2 | +0·1 |
| 3000 | | | 47·1 | 48·4 | −1·3 | | | 40·6 | 40·6 | 0·0 |
| 2900 | | | 47·5 | 48·7 | −1·2 | | | 40·7 | 40·7 | 0·0 |
| 2800 | | | 47·7 | 49·1 | −1·4 | | | 41·1 | 41·1 | 0·0 |
| 2700 | | | 48·0 | 49·6 | −1·6 | | | 41·4 | 41·5 | −0·1 |

From 6h 12m p.m. to 7h 18m p.m. — From 7h 18m p.m. to 8h 9m p.m. — Generally clear sky.

TABLE III. (*continued*).

TWENTY-EIGHTH ASCENT (*continued*).

| 1866. May 29 (*con.*). Height, in feet, above the mean level of the sea. | Temperature of the Air. Ascending. Between what times. | Circumstances. | Observed temp. | Adopted temp. | Calculated effect of disturbance. | Descending. Between what times. | Circumstances. | Observed temp. | Adopted temp. | Calculated effect of disturbance. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | ° | ° | ° | | | ° | ° | ° |
| 2600 | From 6h 12m p.m. to 7h 18m p.m. | | 48·5 | 50·0 | −1·5 | From 7h 18m p.m. to 8h 9m p.m. | Generally clear sky. | 42·0 | 41·9 | +0·1 |
| 2500 | | | 48·9 | 50·3 | −1·4 | | | 42·6 | 42·5 | +0·1 |
| 2400 | | | 49·3 | 50·7 | −1·4 | | | 43·4 | 42·8 | +0·6 |
| 2300 | | | 49·7 | 51·1 | −1·4 | | | 44·1 | 43·3 | +0·8 |
| 2200 | | | 50·5 | 51·5 | −1·0 | | | 44·3 | 43·8 | +0·5 |
| 2100 | | | 51·3 | 51·9 | −0·6 | | | 44·5 | 44·3 | +0·2 |
| 2000 | | | 52·0 | 52·3 | −0·3 | | | 44·8 | 44·5 | +0·3 |
| 1900 | | | 52·7 | 52·7 | 0·0 | | | 45·0 | 45·0 | 0·0 |
| 1800 | | | 53·1 | 53·1 | 0·0 | | | 45·3 | 45·3 | 0·0 |
| 1700 | | | 53·5 | 53·5 | 0·0 | | | 45·7 | 45·7 | 0·0 |
| 1600 | | | 53·8 | 53·8 | 0·0 | | | 46·2 | 46·2 | 0·0 |
| 1500 | | | 54·3 | 54·3 | 0·0 | | | 46·6 | 46·6 | 0·0 |
| 1400 | | | 54·6 | 54·6 | 0·0 | | | 47·1 | 47·1 | 0·0 |
| 1300 | | | 55·0 | 55·0 | 0·0 | | | 47·6 | 47·6 | 0·0 |
| 1200 | | | 55·3 | 55·3 | 0·0 | | | 47·8 | 48·0 | −0·2 |
| 1100 | | | 55·5 | 55·5 | 0·0 | | | 48·1 | 48·5 | −0·4 |
| 1000 | | | 55·8 | 55·8 | 0·0 | | | 48·3 | 49·0 | −0·7 |
| 900 | | | 56·2 | 56·2 | 0·0 | | | 48·8 | 49·5 | −0·7 |
| 800 | | | 56·4 | 56·4 | 0·0 | | | 49·5 | 50·0 | −0·5 |
| 700 | | | 56·7 | 56·7 | 0·0 | | | 50·7 | 50·5 | +0·2 |
| 600 | | | 57·0 | 57·0 | 0·0 | | | 51·8 | 51·0 | +0·8 |
| 500 | | | 57·3 | 57·4 | −0·1 | | | 53·6 | 51·8 | +1·8 |
| 400 | | | 57·5 | 57·6 | −0·1 | | | | | |
| 300 | | | 57·6 | 57·8 | −0·2 | | | | | |
| 200 | | | 57·8 | 58·2 | −0·4 | | | | | |
| 100 | | | 57·9 | 58·5 | −0·6 | | | | | |
| 0 | | | 58·0 | 58·8 | −0·8 | | | | | |
| 6400 | From 8h 9m p.m. to 8h 21m 30s p.m. | Sensibly damp and cold. | 35·2 | 35·2 | 0·0 | From 8h 21m 30s p.m. to 9h 25m p.m. | Mist over the land; cannot see far. | 35·2 | 35·3 | −0·1 |
| 6300 | | | 34·3 | 35·4 | −1·1 | | | 35·2 | 35·4 | −0·2 |
| 6200 | | | 34·2 | 35·5 | −1·3 | | | 35·5 | 35·5 | 0·0 |
| 6100 | | | 34·1 | 35·7 | −1·6 | | | 35·7 | 35·6 | +0·1 |
| 6000 | | | 34·6 | 36·0 | −1·4 | | | 35·8 | 35·8 | 0·0 |
| 5900 | | | 35·4 | 36·3 | −0·9 | | | 35·6 | 36·0 | −0·4 |
| 5800 | | | 36·2 | 36·6 | −0·4 | | | 35·6 | 36·1 | −0·5 |
| 5700 | | | 37·0 | 36·8 | +0·2 | | | 35·8 | 36·2 | −0·4 |
| 5600 | | | 37·8 | 37·0 | +0·8 | | | 36·1 | 36·3 | −0·2 |
| 5500 | | | 38·3 | 37·3 | +1·0 | | | 36·3 | 36·5 | −0·2 |
| 5400 | | | 38·5 | 37·7 | +0·8 | | | 36·5 | 36·6 | −0·1 |
| 5300 | | | 38·6 | 37·9 | +0·7 | | | 36·7 | 36·7 | 0·0 |
| 5200 | | | 38·7 | 38·2 | +0·5 | | | 36·8 | 36·8 | 0·0 |
| 5100 | | | 38·8 | 38·5 | +0·3 | | | 36·9 | 37·0 | −0·1 |
| 5000 | | | 39·0 | 38·8 | +0·2 | | | 37·0 | 37·2 | −0·2 |
| 4900 | | | 39·0 | 39·0 | 0·0 | | | 37·0 | 37·4 | −0·4 |
| 4800 | | | 39·0 | 39·4 | −0·4 | | | 37·0 | 37·5 | −0·5 |
| 4700 | | | 39·1 | 39·7 | −0·6 | | | 37·1 | 37·7 | −0·6 |
| 4600 | | | 39·1 | 40·0 | −0·9 | | | 37·2 | 38·0 | −0·8 |
| 4500 | | | 39·2 | 40·4 | −1·2 | | | 37·4 | 38·3 | −0·9 |
| 4400 | | | 39·2 | 40·7 | −1·5 | | | 37·6 | 38·4 | −0·8 |

TABLE III. (*continued*).

TWENTY-EIGHTH ASCENT (*continued*).

| 1866. May 29 (*con.*). Height, in feet, above the mean level of the sea. | Temperature of the Air. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ascending. | | | | | Descending. | | | | |
| | Between what times. | Circumstances. | Observed temp. | Adopted temp. | Calculated effect of disturbance. | Between what times. | Circumstances. | Observed temp. | Adopted temp. | Calculated effect of disturbance. |
| | | | ° | ° | ° | | | ° | ° | ° |
| 4300 | | | 39·5 | 41·0 | −1·5 | | | 37·8 | 38·6 | −0·8 |
| 4200 | | | 40·0 | 41·2 | −1·2 | | | 38·2 | 38·8 | −0·6 |
| 4100 | | | 40·5 | 41·5 | −1·0 | | | 38·4 | 39·1 | −0·7 |
| 4000 | | | 41·0 | 41·8 | −0·8 | | | 38·6 | 39·3 | −0·7 |
| 3900 | | | 41·5 | 42·2 | −0·7 | | | 38·9 | 39·5 | −0·6 |
| 3800 | | | 42·0 | 42·5 | −0·5 | | | 39·2 | 39·7 | −0·5 |
| 3700 | | | 42·5 | 42·8 | −0·3 | | | 39·5 | 40·0 | −0·5 |
| 3600 | | | 42·9 | 43·1 | −0·2 | | | 39·9 | 40·2 | −0·3 |
| 3500 | | | 43·4 | 43·5 | −0·1 | | | 40·4 | 40·5 | −0·1 |
| 3400 | | | 43·8 | 43·8 | 0·0 | | | 40·7 | 40·7 | 0·0 |
| 3300 | | | 44·3 | 44·3 | 0·0 | | | 41·1 | 41·0 | +0·1 |
| 3200 | | | 44·7 | 44·5 | +0·2 | | | 41·9 | 41·4 | +0·5 |
| 3100 | | | 45·2 | 44·7 | +0·5 | | | 42·7 | 41·7 | +1·0 |
| 3000 | | | 45·6 | 45·1 | +0·5 | | | 43·4 | 42·0 | +1·4 |
| 2900 | | | 46·0 | 45·5 | +0·5 | | | 43·9 | 42·4 | +1·5 |
| 2800 | | | 46·3 | 45·9 | +0·4 | | | 44·1 | 42·7 | +1·4 |
| 2700 | | | 46·6 | 46·3 | +0·3 | | | 44·3 | 43·1 | +1·2 |
| 2600 | | | 47·0 | 46·7 | +0·3 | | | 44·5 | 43·5 | +1·0 |
| 2500 | | | 47·5 | 47·0 | +0·5 | | | 44·8 | 43·8 | +1·0 |
| 2400 | | | 47·8 | 47·4 | +0·4 | | | 45·0 | 44·2 | +0·8 |
| 2300 | | | 48·1 | 47·7 | +0·4 | | | 45·3 | 44·6 | +0·7 |
| 2200 | | | 48·5 | 48·2 | +0·3 | | | 45·5 | 45·1 | +0·4 |
| 2100 | | | 48·7 | 48·5 | +0·2 | | | 45·6 | 45·5 | +0·1 |
| 2000 | | | 49·1 | 48·9 | +0·2 | | | 46·0 | 46·0 | +0·0 |
| 1900 | | | 49·4 | 49·3 | +0·1 | | | 46·4 | 46·4 | 0·0 |
| 1800 | | | 49·7 | 49·6 | +0·1 | | | 46·8 | 46·8 | 0·0 |
| 1700 | | | 50·0 | 49·9 | +0·1 | | | 47·2 | 47·2 | 0·0 |
| 1600 | | | 50·3 | 50·3 | 0·0 | | | 47·5 | 47·5 | 0·0 |
| 1500 | | | 50·6 | 50·6 | 0·0 | | | 48·0 | 48·0 | 0·0 |
| 1400 | | | 51·0 | 51·0 | 0·0 | | | 48·3 | 48·3 | 0·0 |
| 1300 | | | 51·4 | 51·4 | 0·0 | | | 48·7 | 48·7 | 0·0 |
| 1200 | | | 51·7 | 51·7 | 0·0 | | | 49·5 | 49·0 | +0·5 |
| 1100 | | | 52·0 | 52·0 | 0·0 | | | 50·7 | 49·5 | +1·2 |
| 1000 | | | 52·3 | 52·3 | 0·0 | | | 51·9 | 50·0 | +1·9 |
| 900 | | | 52·7 | 52·7 | 0·0 | | | 53·0 | 50·5 | +2·5 |
| 800 | | | 53·0 | 53·0 | 0·0 | | | 53·6 | 51·0 | +2·6 |
| 700 | | | 53·4 | 53·4 | 0·0 | | | 53·8 | 51·4 | +2·4 |
| 600 | | | 53·5 | 53·5 | 0·0 | | | 53·0 | 51·9 | +1·1 |
| 500 | | | 54·0 | 54·0 | 0·0 | | | 52·5 | | |
| 400 | | | | | | | | 52·1 | | |
| 300 | | | | | | | | 51·6 | | |
| 200 | | | | | | | | 51·1 | | |
| 100 | | | | | | | | 50·6 | | |
| 0 | | | | | | | | 50·1 | | |
| | From 8h 9m p.m. to 8h 21m 30s p.m. | | | | | From 8h 21m 30s to 9h 25m p.m. | | | | |

The temperature of the air declined from 58°·0 on the ground to 52° at 2000 feet, and somewhat more rapidly to 46°·7 at 3000 feet; it increased to 48°·7, or by 2° in the next 400 feet, and then gradually declined to 29°·8 at the height of 6200 feet. On descending, the temperature increased gradually to 48°·3 at 1000 feet, and then much more rapidly to 53°·6 at the height of 500 feet: this rapid increase was remarkable. On turning to ascend the sun having set, the temperature declined pretty equally to the height of 4000 feet; and at greater heights, with somewhat less regularity, to 34° at 6000 feet, when the temperature increased to 35°·3 at the height of 6400 feet: this increase was very remarkable. On descending again, the temperature increased with moderate regularity to 48°·7 at the height of 1300 feet, and then with much greater rapidity to 53°·8 at the height of 600 feet, when the increase was arrested, and the temperature at lower elevations rapidly declined, on approaching the earth, to 50°·1. This decline of temperature from 600 feet is remarkable. By comparing the readings at the same heights before and after sunset, it will be seen that at the height of 6000 feet, the temperature was from 5° to 6° warmer after sunset than it was before sunset, and that the temperatures on the ground, and at 1000 feet high, were nearly the same, whilst at intermediate heights they were much higher.

TABLE VI.—Showing the Decrease of Temperature with every increase of 100 feet up to 6400 feet.

| Height, in feet, above the level of the sea. | | Oct. 2, 1865. | | Dec. 2, 1865. | | May 29, 1865. | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | State of the Sky. | | | | | | | |
| | | Clear. | | Cloudy. | | Partially clear and cloudy. | | | |
| From | To | Ascending. | Descending. | Ascending. | Descending. | Ascending. | Descending. | Ascending. | Descending. |
| feet. | feet. | ° | ° | ° | ° | ° | ° | ° | ° |
| 6300 | 6400 | ... | ... | ... | ... | ... | ... | 0·2 | 0·1 |
| 6200 | 6300 | ... | ... | ... | ... | ... | ... | 0·1 | 0·1 |
| 6100 | 6200 | ... | ... | ... | ... | 0·8 | 0·5 | 0·2 | 0·1 |
| 6000 | 6100 | ... | ... | ... | ... | 0·8 | 0·3 | 0·3 | 0·2 |
| 5900 | 6000 | ... | ... | ... | ... | 0·9 | 0·5 | 0·3 | 0·2 |
| 5800 | 5900 | ... | ... | ... | ... | 0·7 | 0·3 | 0·3 | 0·1 |
| 5700 | 5800 | ... | ... | ... | ... | 1·0 | 0·4 | 0·2 | 0·1 |
| 5600 | 5700 | ... | ... | ... | ... | 0·5 | 0·4 | 0·2 | 0·1 |
| 5500 | 5600 | ... | ... | ... | ... | 0·5 | 0·2 | 0·3 | 0·2 |
| 5400 | 5500 | ... | ... | ... | ... | 0·6 | 0·4 | 0·4 | 0·1 |
| 5300 | 5400 | ... | ... | ... | ... | 0·7 | 0·4 | 0·2 | 0·1 |
| 5200 | 5300 | ... | ... | ... | ... | 0·6 | 0·3 | 0·3 | 0·1 |
| 5100 | 5200 | ... | ... | ... | ... | 0·7 | 0·3 | 0·3 | 0·2 |
| 5000 | 5100 | ... | ... | ... | ... | 0·5 | 0·3 | 0·3 | 0·2 |
| 4900 | 5000 | ... | ... | ... | ... | 0·6 | 0·3 | 0·2 | 0·2 |
| 4800 | 4900 | ... | ... | ... | ... | 0·6 | 0·3 | 0·4 | 0·1 |
| 4700 | 4800 | ... | ... | ... | ... | 0·6 | 0·3 | 0·3 | 0·2 |
| 4600 | 4700 | ... | ... | ... | ... | 0·7 | 0·3 | 0·3 | 0·3 |
| 4500 | 4600 | ... | ... | 0·0 | 0·2 | 0·6 | 0·2 | 0·4 | 0·3 |

TABLE VI. (*continued*).

| Height, in feet, above the level of the sea. | | Oct. 2, 1865. | | Dec. 2, 1865. | | May 29, 1866. | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | State of the Sky. | | | | | | | |
| | | Clear. | | Cloudy. | | Partially clear and cloudy. | | | |
| From | To | Ascending. | Descending. | Ascending. | Descending. | Ascending. | Descending. | Ascending. | Descending. |
| feet. | feet. | ° | ° | ° | ° | ° | ° | ° | ° |
| 4400 | 4500 | ... | ... | 0·0 | 0·1 | 0·6 | 0·3 | 0·3 | 0·1 |
| 4300 | 4400 | ... | ... | 0·0 | 0·2 | 0·5 | 0·4 | 0·3 | 0·2 |
| 4200 | 4300 | ... | ... | 0·0 | 0·2 | 0·7 | 0·3 | 0·2 | 0·2 |
| 4100 | 4200 | ... | ... | 0·1 | 0·3 | 0·5 | 0·3 | 0·3 | 0·3 |
| 4000 | 4100 | ... | ... | 0·2 | 0·3 | 0·5 | 0·3 | 0·3 | 0·2 |
| 3900 | 4000 | ... | ... | 0·3 | 0·2 | 0·5 | 0·4 | 0·4 | 0·2 |
| 3800 | 3900 | ... | ... | 0·6 | 0·3 | 0·5 | 0·2 | 0·3 | 0·2 |
| 3700 | 3800 | ... | ... | 0·6 | 0·3 | 0·6 | 0·4 | 0·3 | 0·3 |
| 3600 | 3700 | ... | ... | 0·6 | 0·4 | 0·4 | 0·3 | 0·3 | 0·2 |
| 3500 | 3600 | ... | ... | 0·6 | 0·3 | 0·5 | 0·3 | 0·4 | 0·3 |
| 3400 | 3500 | ... | ... | 0·6 | 0·3 | 0·4 | 0·4 | 0·3 | 0·2 |
| 3300 | 3400 | ... | ... | 0·8 | 0·2 | 0·4 | 0·2 | 0·5 | 0·3 |
| 3200 | 3300 | ... | ... | 0·6 | 0·4 | 0·2 | 0·4 | 0·2 | 0·4 |
| 3100 | 3200 | ... | ... | 0·4 | 0·3 | 0·5 | 0·3 | 0·2 | 0·3 |
| 3000 | 3100 | ... | ... | 0·2 | 0·2 | 0·4 | 0·4 | 0·4 | 0·3 |
| 2900 | 3000 | ... | ... | 0·2 | 0·2 | 0·3 | 0·1 | 0·4 | 0·4 |
| 2800 | 2900 | ... | ... | 0·2 | 0·2 | 0·4 | 0·4 | 0·4 | 0·3 |
| 2700 | 2800 | ... | ... | 0·2 | 0·2 | 0·5 | 0·4 | 0·4 | 0·4 |
| 2600 | 2700 | ... | ... | 0·1 | 0·3 | 0·4 | 0·4 | 0·4 | 0·4 |
| 2500 | 2600 | ... | ... | 0·3 | 0·3 | 0·3 | 0·6 | 0·3 | 0·3 |
| 2400 | 2500 | ... | ... | 0·3 | ... | 0·4 | 0·3 | 0·4 | 0·4 |
| 2300 | 2400 | ... | ... | 0·4 | ... | 0·4 | 0·5 | 0·3 | 0·4 |
| 2200 | 2300 | ... | ... | 0·5 | ... | 0·4 | 0·5 | 0·5 | 0·5 |
| 2100 | 2200 | ... | ... | 0·5 | ... | 0·4 | 0·5 | 0·3 | 0·3 |
| 2000 | 2100 | ... | ... | 0·5 | ... | 0·4 | 0·2 | 0·4 | 0·5 |
| 1900 | 2000 | ... | ... | 0·9 | ... | 0·4 | 0·5 | 0·4 | 0·4 |
| 1800 | 1900 | −0·2 | −0·1 | −0·3 | ... | 0·4 | 0·3 | 0·3 | 0·4 |
| 1700 | 1800 | −0·2 | −0·1 | −0·3 | ... | 0·4 | 0·4 | 0·3 | 0·4 |
| 1600 | 1700 | −0·2 | −0·1 | −0·3 | ... | 0·3 | 0·5 | 0·4 | 0·3 |
| 1500 | 1600 | −0·2 | −0·1 | −0·2 | ... | 0·5 | 0·4 | 0·3 | 0·5 |
| 1400 | 1500 | −0·2 | −0·2 | −0·2 | ... | 0·3 | 0·5 | 0·4 | 0·3 |
| 1300 | 1400 | −0·2 | −0·1 | 0·0 | ... | 0·4 | 0·5 | 0·4 | 0·4 |
| 1200 | 1300 | −0·2 | −0·2 | 0·0 | ... | 0·3 | 0·4 | 0·3 | 0·3 |
| 1100 | 1200 | −0·1 | −0·1 | 0·0 | ... | 0·2 | 0·5 | 0·3 | 0·5 |
| 1000 | 1100 | −0·3 | −0·1 | 0·1 | ... | 0·3 | 0·5 | 0·3 | 0·5 |
| 900 | 1000 | −0·2 | −0·2 | 0·0 | ... | 0·4 | 0·5 | 0·4 | 0·5 |
| 800 | 900 | −0·1 | −0·1 | 0·1 | ... | 0·2 | 0·5 | 0·3 | 0·5 |
| 700 | 800 | −0·2 | −0·2 | 0·0 | ... | 0·3 | 0·5 | 0·4 | 0·4 |
| 600 | 700 | −0·2 | −0·2 | 0·1 | ... | 0·3 | 0·5 | 0·1 | 0·5 |
| 500 | 600 | −0·2 | −0·3 | 0·0 | ... | 0·4 | 0·8 | 0·5 | 0·4 |
| 400 | 500 | −0·1 | −0·2 | 0·0 | ... | 0·2 | ... | ... | 0·3 |
| 300 | 400 | −0·2 | −0·3 | 0·1 | ... | 0·2 | ... | ... | 0·4 |
| 200 | 300 | −0·2 | −0·3 | 0·5 | ... | 0·4 | ... | ... | 0·5 |
| 100 | 200 | −0·2 | −0·3 | 0·5 | ... | 0·3 | ... | ... | 0·5 |
| 0 | 100 | −0·3 | −0·4 | 0·9 | ... | 0·3 | ... | ... | 0·5 |

The sign — denotes an increasing temperature with increase of elevation.

TABLE VII.—Showing the Variation of the Hygrometric condition of the Air at every 100 feet of height.

TWENTY-SIXTH ASCENT.

| 1865. October 2. Height, in feet, above the mean level of the sea. | Humidity of the Air. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ascending. | | | | | Descending. | | | | |
| | Between what times. | Circumstances. | Temperature of the dew-point. | Elastic force of vapour. | Degree of humidity. | Between what times. | Circumstances. | Temperature of the dew-point. | Elastic force of vapour. | Degree of humidity. |
| | | | ° | in. | | | | ° | in. | |
| 2000 | | | 58·0 | ..... | 94 | | | | | |
| 1900 | | | 57·7 | ·477 | 94 | | | 57·8 | ·479 | 92 |
| 1800 | | | 57·6 | ·475 | 95 | | | 57·6 | ·475 | 93 |
| 1700 | | | 57·3 | ·470 | 95 | | | 57·5 | ·473 | 93 |
| 1600 | | | 57·1 | ·467 | 94 | | | 57·5 | ·473 | 94 |
| 1500 | | | 57·0 | ·465 | 94 | | | 57·4 | ·472 | 95 |
| 1400 | | | 56·9 | ·464 | 96 | | | 57·1 | ·467 | 94 |
| 1300 | | | 56·5 | ·457 | 94 | | | 56·9 | ·464 | 94 |
| 1200 | | | 55·9 | ·447 | 93 | | | 56·7 | ·461 | 93 |
| 1100 | From 6h 20m p.m. to 6h 56m p.m. | Generally clear sky. | 55·4 | ·439 | 90 | From 6h 57m p.m. to 8h 20m p.m. | Misty and very dark. | 55·5 | ·441 | 89 |
| 1000 | | | 55·4 | ·439 | 90 | | | 53·9 | ·416 | 83 |
| 900 | | | 56·0 | ·449 | 92 | | | 54·6 | ·427 | 86 |
| 800 | | | 56·1 | ·451 | 94 | | | 54·4 | ·424 | 86 |
| 700 | | | 55·8 | ·446 | 95 | | | 54·3 | ·422 | 86 |
| 600 | | | 55·5 | ·441 | 94 | | | 54·5 | ·425 | 88 |
| 500 | | | 55·3 | ·437 | 94 | | | 55·0 | ·433 | 91 |
| 400 | | | 55·0 | ·433 | 93 | | | 54·8 | ·430 | 93 |
| 300 | | | 54·7 | ·428 | 92 | | | 54·9 | ·431 | 93 |
| 200 | | | 54·5 | ·425 | 93 | | | 55·0 | ·433 | 93 |
| 100 | | | 54·2 | ·421 | 93 | | | 55·1 | ·434 | 94 |
| 0 | | | 54·0 | ·418 | 93 | | | 55·2 | ·436 | 96 |

The temperature of the dew-point increased on ascending to the height of 900 feet, then decreased, the air becoming drier, or the degree of humidity less; at heights exceeding 1200 feet, the degree of humidity was nearly the same as at heights less than 900 feet. On descending, the temperature of the dew-point decreased, and the air was driest at about the height of 1000 feet; at heights less than 1000 feet the temperature of the dew-point increased, and the degree of humidity increased till the ground was reached.

TWENTY-SEVENTH ASCENT.

| December 2. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 4600 | | | 21·7 | ·116 | 79 | | | 21·7 | ·116 | 79 |
| 4500 | | | 21·7 | ·116 | 79 | | | 21·2 | ·114 | 77 |
| 4400 | | | 21·7 | ·116 | 79 | | | 21·5 | ·115 | 78 |
| 4300 | | | 22·4 | ·120 | 81 | | | 24·1 | ·130 | 86 |
| 4200 | From 5h 15m p.m. to 6h 39m 30s p.m. | | 23·0 | ·123 | 84 | From 6h 39m 30s p.m. to 7h 10m p.m. | Very cloudy above. | 25·2 | ·136 | 88 |
| 4100 | | | 22·5 | ·120 | 83 | | | 24·8 | ·134 | 87 |
| 4000 | | | 20·8 | ·112 | 75 | | | 24·6 | ·133 | 84 |
| 3900 | | | 20·0 | ·108 | 70 | | | 24·3 | ·131 | 83 |
| 3800 | | | 20·0 | ·108 | 68 | | | 24·1 | ·130 | 80 |
| 3700 | | | 21·0 | ·113 | 71 | | | 24·7 | ·133 | 81 |
| 3600 | | | 23·0 | ·123 | 75 | | | 25·5 | ·138 | 82 |
| 3500 | | Cold to sense. | 24·4 | ·131 | 78 | | | 27·0 | ·147 | 85 |

TABLE VII. (*continued.*)

TWENTY-SEVENTH ASCENT (*continued*).

| 1865. December 2. Height, in feet, above the mean level of the sea. | Humidity of the Air. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ascending. | | | | | Descending. | | | | |
| | Between what times. | Circumstances. | Temperature of the dew-point. | Elastic force of vapour. | Degree of humidity. | Between what times. | Circumstances. | Temperature of the dew-point. | Elastic force of vapour. | Degree of humidity. |
| | | | ° | in. | | | | ° | in. | |
| 3400 | | | 25·4 | ·137 | 78 | From 6h 39m 30s p.m. to 7h 10m p.m. | | 25·5 | ·138 | 79 |
| 3300 | | | 27·3 | ·149 | 83 | | | 27·9 | ·152 | 88 |
| 3200 | | | 29·1 | ·160 | 88 | | | 28·3 | ·155 | 91 |
| 3100 | | | 30·4 | ·170 | 89 | | | 28·6 | ·157 | 90 |
| 3000 | | | 31·8 | ·179 | 95 | | | 29·0 | ·160 | 89 |
| 2900 | | | 31·8 | ·179 | 95 | | | 29·4 | ·162 | 91 |
| 2800 | | | 31·4 | ·176 | 94 | | | 29·6 | ·164 | 92 |
| 2700 | | | 32·4 | ·184 | 95 | | | 30·0 | ·167 | 92 |
| 2600 | | Clouds below. | 34·0 | ·196 | 100 | | | 30·3 | ·169 | 92 |
| 2500 | | | 32·8 | ·186 | 96 | | Lamp extinguished. | 30·7 | ·172 | 92 |
| 2400 | | | 33·5 | ·192 | 98 | | | | | |
| 2300 | | | 33·9 | ·195 | 98 | | | | | |
| 2200 | | | 34·2 | ·197 | 97 | | | | | |
| 2100 | | | 34·5 | ·199 | 97 | | | | | |
| 2000 | | | 35·1 | ·204 | 98 | | | | | |
| 1900 | | Very cloudy; nothing visible. | 36·7 | ·218 | 99 | | | | | |
| 1800 | From 5h 15m p.m. to 6h 39m 30s p.m. | | 36·7 | ·218 | 99 | | | | | |
| 1700 | | | 36·4 | ·215 | 99 | | | | | |
| 1600 | | | 36·1 | ·213 | 99 | | | | | |
| 1500 | | | 35·8 | ·210 | 99 | | | | | |
| 1400 | | | 35·7 | ·209 | 99 | | | | | |
| 1300 | | | 35·7 | ·209 | 99 | | | | | |
| 1200 | | | 35·7 | ·209 | 99 | | | | | |
| 1100 | | | 35·7 | ·209 | 99 | | | | | |
| 1000 | | | 35·7 | ·209 | 98 | | | | | |
| 900 | | | 35·7 | ·209 | 98 | | | | | |
| 800 | | | 35·7 | ·209 | 98 | | | | | |
| 700 | | | 35·7 | ·209 | 98 | | | | | |
| 600 | | | 35·7 | ·209 | 98 | | | | | |
| 500 | | | 35·7 | ·209 | 98 | | | | | |
| 400 | | | 35·7 | ·209 | 98 | | | | | |
| 300 | | Misty all round. | 35·7 | ·209 | 98 | | | | | |
| 200 | | | 36·3 | ·214 | 98 | | | | | |
| 100 | | | 37·0 | ·220 | 98 | | | | | |
| 0 | | | 37·5 | ·225 | 98 | | | | | |

The temperature of the dew-point on the ground and to the height of 1800 feet was very little below that of the air, and consequently the air was nearly saturated with moisture, and was quite so at 1900 feet high; after this the temperature of the dew-point was again a little below that of the air, till 2600 feet was reached, when the air was again saturated; at heights exceeding this the two temperatures separated more and more, till at 3800 feet high the air was the driest, the degree of humidity being 68 only. At heights exceeding 3900 feet the air became somewhat more damp to 4200 feet high, and then again somewhat less so at 4600 feet.

[illegible]

[illegible]

Humidity of the Air.

| Time. | Ascending. | | | | | Descending. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Barometer without | Thermometer without | Temperature of the dew-point. | Elastic force of vapour. | Degree of humidity. | Barometer without | Circumstances. | Temperature of the dew-point. | Elastic force of vapour. | Degree of humidity. |
| | | | ° | in. | | | | ° | in. | |
| [illegible] | | | | | | | | | | |
| [illegible] | | | | | | | | | | |
| [illegible] | | | [illegible] | [illegible] | [illegible] | | | 21·8 | ·117 | 69 |
| [illegible] | | | [illegible] | [illegible] | [illegible] | | | 21·4 | ·115 | 66 |
| [illegible] | | | [illegible] | [illegible] | [illegible] | | | 21·7 | ·116 | 65 |
| [illegible] | | | [illegible] | [illegible] | [illegible] | | | 24·3 | ·131 | 72 |
| [illegible] | | | [illegible] | [illegible] | [illegible] | | | 26·3 | ·143 | 79 |
| [illegible] | | | [illegible] | [illegible] | [illegible] | | | 28·0 | ·153 | 84 |
| [illegible] | | | [illegible] | [illegible] | [illegible] | | | 27·8 | ·152 | 84 |
| [illegible] | | | [illegible] | [illegible] | [illegible] | | | 27·7 | ·151 | 83 |
| [illegible] | | | [illegible] | [illegible] | [illegible] | | | 27·6 | ·151 | 80 |
| [illegible] | | | [illegible] | [illegible] | [illegible] | | | 27·4 | ·149 | 78 |
| [illegible] | | | [illegible] | [illegible] | [illegible] | | | 27·3 | ·149 | 77 |
| [illegible] | | | [illegible] | [illegible] | [illegible] | | | 27·2 | ·148 | 76 |
| [illegible] | | | [illegible] | [illegible] | [illegible] | | | 27·3 | ·149 | 74 |
| [illegible] | | | [illegible] | [illegible] | [illegible] | | | 27·9 | ·152 | 74 |
| [illegible] | | | [illegible] | [illegible] | [illegible] | | | 28·5 | ·156 | 77 |
| [illegible] | | | [illegible] | [illegible] | [illegible] | | | 29·1 | ·160 | 78 |
| [illegible] | | | [illegible] | [illegible] | [illegible] | | | 29·7 | ·165 | 77 |
| [illegible] | | | [illegible] | [illegible] | [illegible] | | | 30·2 | ·168 | 77 |
| [illegible] | | | [illegible] | [illegible] | [illegible] | | | 30·8 | ·172 | 82 |
| [illegible] | | | [illegible] | [illegible] | [illegible] | | | 31·4 | ·176 | 83 |
| [illegible] | | | [illegible] | [illegible] | [illegible] | | | 32·1 | ·182 | 84 |
| [illegible] | | | [illegible] | [illegible] | [illegible] | | | 32·8 | ·186 | 84 |
| [illegible] | | | [illegible] | [illegible] | [illegible] | | | 33·2 | ·189 | 85 |
| [illegible] | | | [illegible] | [illegible] | [illegible] | | | 33·4 | ·191 | 87 |
| [illegible] | | | [illegible] | [illegible] | [illegible] | | | 33·6 | ·193 | 85 |
| [illegible] | | | [illegible] | [illegible] | [illegible] | | | 33·8 | ·194 | 82 |
| [illegible] | | | [illegible] | [illegible] | [illegible] | | | 34·0 | ·196 | 84 |
| [illegible] | | | [illegible] | [illegible] | [illegible] | | | 34·1 | ·196 | 82 |
| 3400 | From 6h 18m to 7h 18m p.m. | Misty. Blue sky above. Sun visible. | 34·6 | ·200 | 57 | From 7h 18m to 8h 0m p.m. | Generally clear sky. | 34·0 | ·196 | 83 |
| 3300 | | | 35·1 | ·204 | 59 | | | 34·0 | ·196 | 79 |
| 3200 | | | 37·0 | ·220 | 67 | | | 33·9 | ·195 | 79 |
| 3100 | | | 40·9 | ·256 | 78 | | | 34·0 | ·196 | 78 |
| 3000 | | | 40·5 | ·252 | 79 | | | 34·0 | ·196 | 76 |
| 2900 | | | 40·1 | ·248 | 75 | | | 34·0 | ·196 | 79 |
| 2800 | | | 39·8 | ·245 | 73 | | | 34·0 | ·196 | 77 |
| 2700 | | | 39·6 | ·243 | 73 | | | 34·0 | ·196 | 75 |
| 2600 | | | 39·6 | ·243 | 70 | | | 34·3 | ·198 | 75 |
| 2500 | | | 39·7 | ·244 | 68 | | | 34·7 | ·201 | 74 |
| 2400 | | | 39·7 | ·244 | 68 | | | 35·1 | ·204 | 70 |
| 2300 | | | 40·0 | ·247 | 67 | | | 35·5 | ·208 | 70 |
| 2200 | | | 40·4 | ·251 | 67 | | | 35·6 | ·208 | 70 |
| 2100 | | | 40·9 | ·256 | 66 | | | 35·7 | ·209 | 70 |
| 2000 | | | 41·5 | ·262 | 70 | | | 35·8 | ·210 | 70 |
| 1900 | | | 42·0 | ·269 | 65 | | | 35·8 | ·210 | 69 |
| 1800 | | | 43·7 | ·285 | 70 | | | 35·0 | ·204 | 64 |
| 1700 | | | 45·5 | ·305 | 74 | | | 36·1 | ·213 | 67 |

TABLE VII. (*continued*).

TWENTY-EIGHTH ASCENT (*continued*).

| 1866. May 29. Height, in feet, above the mean level of the sea. | Humidity of the Air. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ascending. | | | | | Descending. | | | | |
| | Between what times. | Circumstances. | Temperature of the dew-point. | Elastic force of vapour. | Degree of humidity. | Between what times. | Circumstances. | Temperature of the dew-point. | Elastic force of vapour. | Degree of humidity. |
| | | | ° | in. | | | | ° | in. | |
| 1600 | From 6h 12m to 7h 18m p.m. | | 46·2 | ·313 | 73 | From 7h 18m p.m. to 8h 9m p.m. | Generally clear sky. | 36·3 | ·214 | 69 |
| 1500 | | | 47·5 | ·329 | 76 | | | 36·5 | ·216 | 67 |
| 1400 | | | 48·7 | ·344 | 76 | | | 36·7 | ·218 | 68 |
| 1300 | | | 49·9 | ·360 | 83 | | | 36·9 | ·219 | 66 |
| 1200 | | | 50·8 | ·371 | 85 | | | 37·1 | ·221 | 65 |
| 1100 | | | 51·1 | ·375 | 85 | | | 37·5 | ·225 | 67 |
| 1000 | | | 51·5 | ·381 | 85 | | | 37·8 | ·227 | 66 |
| 900 | | | 51·8 | ·385 | 85 | | | 39·0 | ·238 | 66 |
| 800 | | | 52·2 | ·391 | 85 | | | 40·0 | ·247 | 68 |
| 700 | | | 52·6 | ·397 | 86 | | | 40·5 | ·252 | 67 |
| 600 | | | 53·0 | ·403 | 86 | | | 40·9 | ·256 | 64 |
| 500 | | | 53·0 | ·403 | 86 | | | 41·5 | ·262 | 63 |
| 400 | | | 52·8 | ·401 | 83 | | | | | |
| 300 | | | 52·7 | ·399 | 82 | | | | | |
| 200 | | | 52·5 | ·396 | 81 | | | | | |
| 100 | | | 52·4 | ·394 | 81 | | | | | |
| 0 | | | 52·4 | ·394 | 81 | | | | | |
| 6400 | From 8h 9m p.m. to 8h 21m 30s p.m. | Sensibly damp and cold. | 34·5 | ·199 | 98 | From 8h 21m 30s p.m. to 9h 25m p.m. | Mist over the earth; cannot see far. | 34·6 | ·200 | 97 |
| 6300 | | | 34·1 | ·196 | 100 | | | 34·5 | ·199 | 97 |
| 6200 | | | 33·8 | ·194 | 99 | | | 33·4 | ·191 | 93 |
| 6100 | | | 33·7 | ·193 | 99 | | | 32·5 | ·184 | 82 |
| 6000 | | | 34·0 | ·196 | 99 | | | 32·3 | ·183 | 81 |
| 5900 | | | 35·0 | ·204 | 99 | | | 32·1 | ·182 | 84 |
| 5800 | | | 35·8 | ·210 | 99 | | | 31·9 | ·180 | 83 |
| 5700 | | | 36·6 | ·217 | 99 | | | 31·7 | ·179 | 82 |
| 5600 | | | 37·5 | ·225 | 99 | | | 31·5 | ·177 | 83 |
| 5500 | | | 38·2 | ·231 | 100 | | | 31·3 | ·176 | 81 |
| 5400 | | | 38·2 | ·231 | 99 | | | 31·1 | ·174 | 79 |
| 5300 | | | 38·2 | ·231 | 99 | | | 31·0 | ·174 | 77 |
| 5200 | | | 38·1 | ·230 | 99 | | | 31·2 | ·175 | 76 |
| 5100 | | | 38·0 | ·229 | 97 | | | 31·4 | ·176 | 79 |
| 5000 | | | 37·8 | ·227 | 96 | | | 31·7 | ·179 | 82 |
| 4900 | | | 37·7 | ·226 | 96 | | | 32·0 | ·181 | 83 |
| 4800 | | | 37·5 | ·225 | 95 | | | 32·3 | ·183 | 83 |
| 4700 | | | 37·3 | ·223 | 94 | | | 32·5 | ·184 | 84 |
| 4600 | | | 37·2 | ·222 | 94 | | | 32·9 | ·187 | 84 |
| 4500 | | | 36·9 | ·219 | 92 | | | 33·3 | ·190 | 84 |
| 4400 | | | 36·8 | ·218 | 92 | | | 33·5 | ·192 | 83 |
| 4300 | | | 37·0 | ·220 | 92 | | | 33·8 | ·194 | 82 |
| 4200 | | | 37·4 | ·224 | 91 | | | 34·0 | ·196 | 84 |
| 4100 | | | 37·7 | ·226 | 90 | | | 34·3 | ·198 | 84 |
| 4000 | | | 38·0 | ·229 | 90 | | | 34·6 | ·200 | 83 |
| 3900 | | | 38·5 | ·233 | 89 | | | 34·9 | ·203 | 85 |
| 3800 | | | 38·8 | ·236 | 89 | | | 35·1 | ·204 | 86 |
| 3700 | | | 39·0 | ·238 | 87 | | | 35·1 | ·204 | 83 |
| 3600 | | | 39·0 | ·238 | 86 | | | 34·8 | ·202 | 82 |
| 3500 | | | 39·0 | ·238 | 85 | | | 34·5 | ·199 | 80 |
| 3400 | | | 39·0 | ·238 | 81 | | | 34·2 | ·197 | 76 |

TABLE VII. (*continued*).

TWENTY-EIGHTH ASCENT (*continued*).

| 1866. May 29. Height, in feet, above the mean level of the sea. | Humidity of the Air. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ascending. | | | | | Descending. | | | | |
| | Between what times. | Circumstances. | Temperature of the dew-point. | Elastic force of vapour. | Degree of humidity. | Between what times. | Circumstances. | Temperature of the dew-point. | Elastic force of vapour. | Degree of humidity. |
| | | | ° | in. | | | | ° | in. | |
| 3300 | From 8h 9m p.m. to 8h 21m 30s p.m. | | 39·0 | ·238 | 87 | From 8h 21m 30s p.m. to 9h 2·5m p.m. | | 34·5 | ·199 | 78 |
| 3200 | | | 38·9 | ·237 | 77 | | | 35·0 | ·204 | 77 |
| 3100 | | | 38·9 | ·237 | 77 | | | 35·8 | ·210 | 76 |
| 3000 | | | 38·9 | ·237 | 75 | | | 36·5 | ·216 | 76 |
| 2900 | | | 38·9 | ·237 | 77 | | | 36·9 | ·219 | 79 |
| 2800 | | | 38·8 | ·236 | 76 | | | 37·0 | ·220 | 76 |
| 2700 | | | 38·8 | ·236 | 75 | | | 37·0 | ·220 | 75 |
| 2600 | | | 38·8 | ·236 | 74 | | | 37·0 | ·220 | 75 |
| 2500 | | | 38·8 | ·236 | 73 | | | 37·0 | ·220 | 74 |
| 2400 | | | 38·8 | ·236 | 72 | | | 37·1 | ·221 | 74 |
| 2300 | | | 38·8 | ·236 | 71 | | | 37·1 | ·221 | 73 |
| 2200 | | | 38·8 | ·236 | 70 | | | 37·1 | ·221 | 73 |
| 2100 | | | 39·0 | ·238 | 69 | | | 37·2 | ·222 | 73 |
| 2000 | | | 39·3 | ·240 | 69 | | | 37·3 | ·223 | 73 |
| 1900 | | | 39·5 | ·242 | 69 | | | 37·8 | ·227 | 73 |
| 1800 | | | 39·8 | ·245 | 69 | | | 38·3 | ·231 | 73 |
| 1700 | | | 40·2 | ·249 | 69 | | | 38·8 | ·236 | 73 |
| 1600 | | | 40·4 | ·251 | 69 | | | 39·2 | ·239 | 72 |
| 1500 | | | 40·7 | ·254 | 69 | | | 39·5 | ·242 | 72 |
| 1400 | | | 40·8 | ·255 | 68 | | | 40·1 | ·248 | 71 |
| 1300 | | | 40·8 | ·255 | 68 | | | 40·5 | ·252 | 71 |
| 1200 | | | 40·9 | ·256 | 67 | | | 41·0 | ·257 | 70 |
| 1100 | | | 40·9 | ·256 | 67 | | | 42·0 | ·267 | 71 |
| 1000 | | | 41·0 | ·257 | 66 | | | 42·8 | ·275 | 71 |
| 900 | | | 41·2 | ·259 | 66 | | | 43·8 | ·286 | 71 |
| 800 | | | 41·3 | ·260 | 65 | | | 43·8 | ·286 | 68 |
| 700 | | | 41·5 | ·262 | 64 | | | 43·0 | ·277 | 61 |
| 600 | | | 41·5 | ·262 | 63 | | | 40·0 | ·247 | 61 |
| 500 | | | 41·7 | ·264 | 63 | | | 39·9 | ·246 | 62 |
| 400 | | | | | | | | 39·8 | ·245 | 64 |
| 300 | | | | | | | | 39·7 | ·244 | 64 |
| 200 | | | | | | | | 39·6 | ·243 | 65 |
| 100 | | | | | | | | 39·6 | ·243 | 66 |
| 0 | | | | | | | | 39·5 | ·242 | 68 |

The degree of humidity of the air increased from the ground to the height of 500 feet; from this height to 1200 feet the air was somewhat less humid, and still less so at heights exceeding 1200 feet. At the height of 3400 feet the degree of humidity was 57 only; the air was again wet at 4800 feet, and somewhat less so at heights exceeding 5000 feet. On descending, the humidity of the air was more uniform down to the height of 3400 feet, and below this the air was less humid than at the same elevations on the ascent, and particularly at low elevations. On descending below 400 feet, I packed up the instruments, for fear of the balloon striking the ground; at this time the sun was setting. On ascending again, after sunset, the air was more and more humid, and most so at 6300 feet; and the same we found in the descent, to the height of 600 feet, where the degree of humidity was 61, and it increased to 68 on the ground.

TABLE VIII.—Showing the degree of Humidity at every 200 feet.

| Height above the level of the sea. | Oct. 2, 1865. | | Dec. 2, 1865. | | May 29, 1866. | | | |
|---|---|---|---|---|---|---|---|---|
| | State of the Sky. | | | | | | | |
| | Clear. | | Cloudy. | | Partially clear and cloudy. | | | |
| | Ascending. | Descending. | Ascending. | Descending. | Ascending. | Descending. | Ascending. | Descending. |
| feet. | | | | | | | | |
| 6400 | .. | .. | .. | .. | .. | .. | 98 | 97 |
| 6200 | .. | .. | .. | .. | 76 | 69 | 99 | 93 |
| 6000 | .. | .. | .. | .. | 78 | 65 | 99 | 81 |
| 5800 | .. | .. | .. | .. | 81 | 79 | 99 | 83 |
| 5600 | .. | .. | .. | .. | 86 | 84 | 99 | 83 |
| 5400 | .. | .. | .. | .. | 85 | 80 | 99 | 79 |
| 5200 | .. | .. | .. | .. | 87 | 77 | 99 | 76 |
| 5000 | .. | .. | .. | .. | 87 | 74 | 96 | 82 |
| 4800 | .. | .. | .. | .. | 91 | 77 | 95 | 83 |
| 4600 | .. | .. | 79 | 79 | 90 | 77 | 94 | 84 |
| 4400 | .. | .. | 79 | 78 | 82 | 82 | 92 | 83 |
| 4200 | .. | .. | 84 | 88 | 70 | 84 | 91 | 84 |
| 4000 | .. | .. | 75 | 84 | 68 | 85 | 90 | 83 |
| 3800 | .. | .. | 68 | 80 | 65 | 85 | 89 | 86 |
| 3600 | .. | .. | 75 | 82 | 64 | 84 | 86 | 82 |
| 3400 | .. | .. | 78 | 79 | 57 | 83 | 81 | 76 |
| 3200 | .. | .. | 88 | 91 | 67 | 79 | 77 | 77 |
| 3000 | .. | .. | 95 | 89 | 79 | 76 | 75 | 76 |
| 2800 | .. | .. | 94 | 92 | 73 | 77 | 76 | 76 |
| 2600 | .. | .. | 100 | 92 | 70 | 75 | 74 | 75 |
| 2400 | .. | .. | 98 | .. | 68 | 70 | 72 | 74 |
| 2200 | .. | .. | 97 | .. | 67 | 70 | 70 | 73 |
| 2000 | .. | .. | 98 | .. | 60 | 70 | 69 | 73 |
| 1800 | 95 | 93 | 99 | ... | 70 | 64 | 69 | 73 |
| 1600 | 94 | 94 | 99 | .. | 73 | 69 | 69 | 72 |
| 1400 | 96 | 94 | 99 | .. | 76 | 68 | 68 | 71 |
| 1200 | 93 | 93 | 99 | .. | 85 | 65 | 67 | 70 |
| 1000 | 90 | 83 | 98 | .. | 85 | 66 | 66 | 71 |
| 800 | 94 | 86 | 98 | .. | 85 | 68 | 65 | 68 |
| 600 | 94 | 88 | 98 | .. | 86 | 64 | 63 | 61 |
| 400 | 93 | 93 | 98 | .. | 83 | ... | .. | 64 |
| 200 | 93 | 93 | 98 | .. | 81 | .. | .. | 65 |
| 0 | 93 | 96 | 98 | .. | 81 | .. | .. | 68 |

Meteorological Observations made in connexion with the Balloon Ascent on October 2, 1865.—Royal Observatory, Greenwich.

| Time of observation. | Reading of Barom. reduced to 32° F. | Reading of Thermom. Dry. | Reading of Thermom. Wet. | Temp. of the dew-point. | Tension of vapour. | Degree of humidity. | Direction of wind. | Amount of cloud 0–10. | Amount of ozone. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|
| h m | in. | ° | ° | ° | in. | | | | | |
| 6 0 p.m. | 29·840 | 60·0 | 57·2 | 54·8 | ·430 | 83 | E.S.E. | 0 | 0 | Cloudless; a very fine bri |
| 6 10 „ | 29·840 | 60·0 | 57·2 | 54·8 | ·430 | 83 | E.S.E. | 0 | 0 | evening; dew. |
| 6 20 „ | 29·842 | 59·9 | 57·2 | 54·9 | ·431 | 84 | E. by S. | 0 | 0 | |
| 6 30 „ | 29·843 | 59·5 | 57·1 | 55·0 | ·433 | 86 | E.S.E. | 0 | 0 | Cloudless. Balloon first s |
| | | | | | | | | | | 6h 30m 15s. Due East of |
| | | | | | | | | | | servatory. |
| 6 40 „ | 29·845 | 59·3 | 57·1 | 55·1 | ·434 | 87 | E.S.E. | 0 | 0 | Cloudless. Balloon passed |
| | | | | | | | | | | of the observatory about |
| | | | | | | | | | | 38m. |
| 6 50 „ | 29·845 | 59·3 | 57·1 | 55·1 | ·434 | 87 | E. by S. | 0 | 0 | Cloudless. Balloon last s |
| | | | | | | | | | | at 6h 46m, moving in a d |
| | | | | | | | | | | Westerly direction—disa |
| | | | | | | | | | | peared in the gloom |
| | | | | | | | | | | London. |
| 7 0 „ | 29·849 | 59·0 | 57·1 | 55·4 | ·439 | 89 | E.S.E. | 0 | 0 | |
| 7 10 „ | 29·853 | 58·6 | 57·0 | 55·6 | ·443 | 89 | E. by S. | 0 | 0 | |
| 7 20 „ | 29·856 | 58·5 | 57·0 | 55·7 | ·444 | 90 | E. | 0 | 0 | |
| 7 30 „ | 29·860 | 58·2 | 56·8 | 55·5 | ·441 | 91 | E. by N. | 0 | 0 | |
| 7 40 „ | 29·869 | 57·4 | 56·2 | 55·1 | ·434 | 92 | E.N.E. | 0 | 0 | |
| 7 50 „ | 29·870 | 57·2 | 56·2 | 55·3 | ·437 | 93 | E. by N. | 0 | 0 | |
| 8 0 „ | 29·873 | 56·7 | 56·0 | 55·4 | ·439 | 95 | E. | 0 | 0 | Cloudless. Heavy dew. |
| 8 10 „ | 29·873 | 56·7 | 55·9 | 55·2 | ·436 | 94 | E. by N. | 0 | 0 | |
| 8 20 „ | 29·873 | 56·0 | 55·6 | 55·2 | ·436 | 97 | E. | 0 | 0 | |
| 8 30 „ | 29·880 | 55·7 | 55·2 | 54·8 | ·430 | 97 | E. | 0 | 0 | |
| 8 40 „ | 29·887 | 55·5 | 55·0 | 54·6 | ·427 | 96 | E. | 0 | 0 | |
| 8 50 „ | 29·888 | 55·6 | 55·0 | 54·5 | ·425 | 96 | E. | 0 | 0 | |
| 9 0 „ | 29·892 | 55·6 | 55·0 | 54·5 | ·425 | 96 | E. | 0 | 1 | |

December 2, 1865.—Royal Observatory, Greenwich.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 5 0 p.m. | 29·594 | 38·6 | 37·1 | 35·2 | ·205 | 88 | S.E. | 6 | 0 | Cirrus and cirrostrat |
| 5 10 „ | 29·593 | 39·0 | 37·4 | 35·3 | ·206 | 87 | ..... | 8 | 0 | Dew falling rapidly. |
| 5 20 „ | 29·593 | 39·1 | 37·6 | 35·7 | ·209 | 88 | ..... | 9 | 0 | |
| 5 30 „ | 29·592 | 39·1 | 37·8 | 35·7 | ·209 | 88 | ..... | 10 | 0 | The sky is covered wi |
| 5 40 „ | 29·590 | 39·1 | 37·8 | 35·7 | ·209 | 88 | ..... | 10 | 0 | clouds. |
| 5 50 „ | 29·588 | 39·2 | 38·0 | 36·4 | ·215 | 90 | ..... | 10 | 0 | |
| 6 0 „ | 29·579 | 39·1 | 38·0 | 36·6 | ·217 | 91 | ..... | | 0 | Generally overcast with cir |
| | | | | | | | | | | stratus and cumulostrat |
| | | | | | | | | | | clouds broken in S.E. |
| 6 10 „ | 29·576 | 39·0 | 37·9 | 36·5 | ·216 | 91 | ..... | 10 | 0 | Generally overcast, clou |
| 6 20 „ | 29·576 | 39·0 | 38·0 | 36·7 | ·218 | 92 | ..... | 10 | 0 | broken in zenith. |
| 6 30 „ | 29·575 | 39·4 | 38·4 | 37·1 | ·221 | 92 | ..... | 10 | 0 | Overcast. |
| 6 40 „ | 29·573 | 39·7 | 38·6 | 37·2 | ·222 | 92 | ..... | 10 | 0 | |
| 6 50 „ | 29·571 | 39·8 | 38·7 | 36·7 | ·218 | 92 | ..... | 10 | 0 | Generally overcast, clou |
| 7 0 „ | 29·571 | 40·1 | 38·9 | 37·4 | ·224 | 90 | ..... | 10 | 0 | broken in S.E. |
| 7 10 „ | 29·570 | 40·2 | 39·0 | 37·5 | ·225 | 90 | ..... | 10 | 0 | |
| 7 20 „ | 29·568 | 40·7 | 39·4 | 37·8 | ·227 | 90 | ..... | 10 | 0 | |
| 7 30 „ | 29·566 | 40·9 | 39·4 | 37·9 | ·228 | 88 | ..... | 10 | 0 | Overcast. |
| 7 40 „ | 29·563 | 41·0 | 39·3 | 37·2 | ·222 | 86 | ..... | 10 | 0 | |

Meteorological Observations made in connexion with the Balloon Ascent on May 29, 1866.—Royal Observatory, Greenwich.

| Time of observation. | Reading of Barom. reduced to 32° F. | Reading of Thermom. Dry. | Reading of Thermom. Wet. | Temp. of the dew-point. | Tension of vapour. | Degree of humidity. | Direction of wind. | Amount of cloud 0–10. | Amount of ozone. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|
| m | in. | ° | ° | ° | in. | | | | | |
| 0p.m. | 29·703 | 59·3 | 50·3 | 42·3 | ·270 | 53 | N. by E. | 8 | 2 | Cirrostratus and cirrocumulus. |
| 10 „ | 29·704 | 58·7 | 49·4 | 41·1 | ·258 | 53 | ..... | 7 | 3 | Sun obscured. |
| 20 „ | 29·707 | 58·4 | 49·0 | 40·6 | ·253 | 53 | ..... | 6 | 3 | Sun shining. |
| 30 „ | 29·708 | 57·9 | 49·0 | 41·0 | ·257 | 57 | ..... | 5 | 3 | Sun shining. |
| 40 „ | 29·713 | 57·6 | 49·0 | 41·2 | ·259 | 57 | ..... | 6 | 3 | Sun obscured. |
| 50 „ | 29·717 | 57·5 | 49·0 | 41·3 | ·260 | 57 | ..... | 6 | 3 | |
| 0 „ | 29·718 | 57·2 | 48·9 | 41·0 | ·260 | 56 | N. | 6 | 3 | Sun shining. |
| 10 „ | 29·721 | 56·1 | 48·0 | 40·4 | ·251 | 55 | ..... | 6 | 3 | Sun obscured. |
| 20 „ | 29·729 | 56·0 | 47·8 | 40·0 | ·247 | 57 | ..... | 8 | 3 | |
| 30 „ | 29·729 | 56·8 | 48·0 | 40·7 | ·254 | 57 | ..... | 9 | 3 | |
| 40 „ | 29·729 | 55·4 | 47·6 | 40·2 | ·249 | 57 | ..... | 9 | 3 | Cirrostratus. |
| 50 „ | 29·742 | 55·1 | 47·1 | 39·4 | ·241 | 56 | ..... | 9 | 3 | Overcast nearly. |
| 0 „ | 29·742 | 54·6 | 47·0 | 39·6 | ·243 | 58 | ..... | 9 | 3 | |
| 10 „ | 29·752 | 54·5 | 47·0 | 39·7 | ·244 | 59 | ..... | 9 | 3 | |
| 20 „ | 29·758 | 54·4 | 46·9 | 39·6 | ·243 | 59 | ..... | 10 | 3 | Overcast. |
| 30 „ | 29·759 | 53·8 | 46·4 | 39·2 | ·239 | 59 | ..... | 10 | 3 | |
| 40 „ | 29·760 | 53·5 | 46·6 | 39·8 | ·245 | 60 | ..... | 10 | 3 | |
| 50 „ | 29·762 | 53·1 | 46·0 | 38·9 | ·237 | 59 | ..... | 10 | 3 | |
| 0 „ | 29·763 | 53·2 | 46·0 | 38·8 | ·236 | 59 | ..... | 10 | 3 | |
| 10 „ | 29·765 | 52·7 | 45·7 | 38·7 | ·235 | 60 | ..... | 10 | 3 | |
| 20 „ | 29·769 | 52·4 | 45·0 | 37·5 | ·225 | 57 | ..... | 10 | 3 | |
| 30 „ | 29·772 | 52·1 | 44·6 | 37·0 | ·220 | 57 | N. by E. | 10 | 3 | |

## *Report on the Extinct Birds of the Mascarene Islands. By a Committee consisting of* Professor A. Newton, Rev. H. B. Tristram, *and* Dr. Sclater.

Almost immediately after the appointment of the Committee, intelligence was received in England of the very important discovery by Mr. George Clark, of Mahébourg, in Mauritius, of a large deposit of bones of the true Dodo (*Didus ineptus*), in a marsh known as the 'Mare aux Songes,' an account of which that gentleman has published in 'The Ibis' Magazine for April 1866. Several fine series of these bones having been sent to England, some were purchased by the Trustees of the British Museum, and formed the subject of a memoir "On the Osteology of the Dodo," read by Professor Owen at a meeting of the Zoological Society of London, 9th January, 1866. This memoir is understood to be nearly ready for publication, and will appear, copiously illustrated, in the 'Transactions' of that Society. Some other fine series of these bones have, by the liberality of Mr. Clark, passed into the possession of one of the members of your Committee; and a portion of them is now exhibited. Several smaller series of bones have likewise been variously distributed by sale or gift both in England and on the Continent, so that numerous Museums (one of these smaller series forms the subject of some "Remarques" communicated to the Academy of Sciences of Paris, 23rd April,

1866, by M. Alphonse Milne-Edwards) and collections have reaped the benefit of Mr. Clark's valuable discovery, the importance of which may be better appreciated when it is remembered that previously the only remains of the Dodo known to naturalists were the head and foot at Oxford, the skull at Copenhagen, the portion of an upper mandible at Prague, and the foot in the British Museum. Now it is believed that every bone of the bird's skeleton has been recovered, with the exception (though that is an important exception) of the extremity of the wing.

The attention of Mr. Edward Newton has been especially called to this deficiency, which seems likely to be supplied by a thorough and systematic examination of the Mare aux Songes, or at least the part of it which has been most prolific in Dodos' bones. That gentleman has accordingly determined to carry out this undertaking as far as may be expedient; but according to the latest accounts received from him, he had been obliged to defer commencing operations in this quarter till the expiration of the rainy season, as the marsh still continued to hold much water, and he expected to be able to do no real good there until next month, when the Committee hope that complete success may attend his excavations.

The collection of bones formed in Rodriguez last year by Mr. George Jenner, and sent home by Mr. Edward Newton (as stated in the communication made by that gentleman to this Section at Birmingham) arrived safely in England in the course of the autumn; and the majority of them proved to belong to the Solitaire or Dodo, peculiar to that island (*Pezophaps solitaria*). They were exhibited at a meeting of the Zoological Society, 23rd November, 1866; and a select series of specimens from them is now produced, among which are several that were previously unknown—such as the proximal end of the tibia, portions of the pelvis and coracoid, the ulna, radius, and phalanx. Mr. Edward Newton has been very desirous of completing the exploration of the caves in Rodriguez, in the hope of finding the remaining portions of the Solitaire's skeleton; but communications between that island and Mauritius being suspended for a large portion of the year, and when existing, being uncertain, the difficulties in the way of carrying out his design were much increased. At last, after long delay, he was informed that labourers were so scarce in Rodriguez that the necessary assistance was not to be obtained for making excavations there. To meet this new and unexpected difficulty he was compelled to hire men in Mauritius and send them to Rodriguez, under engagement for the express purpose of digging in the caves. The Committee trust that the best results may follow this mission.

Bourbon or Réunion, the third of the Mascarene Islands, which is known to have formerly possessed a Didine bird, has not been neglected by the Committee; but they regret to say that at present they see no chance of successfully carrying on researches there. Mr. Edward Newton, however, is thoroughly alive to the importance of discovering the remains of this species (of which, unlike its allies, not a single relic is on record as now existing): and he has commissioned a gentleman, who has lately proceeded thither, to make a preliminary survey in the hope of finding places likely to reward a search for its remains.

## *Report on various Experiments carried out by* Captain W. H. Noble, R.A., *under the direction of the Ordnance Select Committee, relative to the Penetration of Iron Armour Plates by Steel shot, to which is added a Memorandum on the Penetration of Iron-Clad Ships by Steel and other Projectiles.*

[A communication ordered to be printed among the Reports.]

In 1862 the Special Committee on Iron proposed a series of experiments for the purpose of ascertaining whether the penetration of projectiles into iron was proportional to their *vis viva*.

The guns proposed for use were the 68-pounder smooth-bore, and 7-inch B L rifled gun, and the necessary charges were determined by the Ordnance Select Committee with the aid of Navez's Electroballistic Apparatus.

A few experiments were subsequently made; but the results were not to be relied on, as the projectiles used were cast iron and broke up on impact. This subject was revived in 1864 by the Ordnance Select Committee, and a series of experiments were authorized for the purpose of determining the following points:—

First. To determine the relative penetrating effects of two shots on an iron plate, provided they strike with the same "work"*, notwithstanding that the one may be heavy with a low velocity, and the other light with a high velocity.

Secondly. To determine the relative resistances of a plate to penetration by two shots of similar form of head, and striking with "work" proportional to their respective diameters.

An example of the first point may be stated as follows:—The 10″·5 wrought-iron gun of 12 tons is fired at an iron plate with a charge of 50 lbs., and spherical steel shot of 168¼ lbs., the velocity at 200 yards being 1576 feet, and consequent "work" 2898 foot-tons†.

The same gun is fired in its rifled state at a similar plate, with a charge of 40 lbs., and hemispherical-headed steel elongated shot of 300 lbs., the velocity at 200 yards being 1180 feet, and consequent "work" 2898 foot-tons.

Will the penetration‡ be the same in both cases?

The following case will serve to illustrate the second point:—

The 100-pounder smooth-bore gun of 6¼ tons is fired at an iron plate with a charge of 15·4 lbs., and spherical steel shot of 104·1 lbs. weight and 8·87 inches diameter, the velocity at 100 yards being 1254 feet, and consequent "work" 1135 foot-tons.

The 7-inch M L rifled gun of 130 cwt. is fired at a similar plate, with a charge of 13·5 lbs., and elongated hemispherical-headed steel shot of 100·3 lbs. weight and 6·92 inches diameter, the velocity at 100 yards being 1129 feet, and consequent "work" 886 foot-tons. Will the penetration‡ be the same in both cases, the *vis viva* being proportional to the respective diameters, or as 8·87 to 6·92?

* $\frac{Wv^2}{2g}$, where W = weight of shot,
$v$ = velocity on impact,
$g$ = the accelerating force of gravity.

† *Vis viva* has been given in foot-tons instead of foot-pounds, in consequence of the number of figures required to express the latter.

‡ By *penetration* is meant actual *perforation* through the plate, or the power of passing through the plate. In the case of penetration *into* iron plates the term "*indent*" has been used.

The experiments which the Ordnance Select Committee instituted for the purpose of obtaining a solution to the foregoing questions must be regarded as preliminary to any inquiry into the larger question of the penetration of iron defences by steel projectiles. No attempt has been made to found any *absolute* law of resistance upon the following results; for these results are not sufficiently extensive to warrant any such proceeding. They were carried out for the purpose of affording a *practical* solution to the questions at issue, and were limited in extent by considerations of expense. To found any *general* law of penetration *into* iron defences would require a much more extensive and costly trial; and although the results of such an investigation might be highly interesting as a philosophical question, it is doubtful whether they would prove of sufficient practical utility to warrant the unavoidable expense*.

When it is considered that this question is surrounded by difficulties and causes of error over which we have no control, it will appear that it is at present hopeless to look for anything but an approximate result. The very quality of the materials we are obliged to make use of, the rough and practical nature of the trials, and the necessity of carrying them out on a moderate scale, all tend to make the experiments, philosophically considered, imperfect and insufficient as a basis for mathematical analysis.

The following programme of experiments was determined on for the first point:—

*Gun.*—6·3-inch M L rifled gun (Shunt†).

*Projectiles.*—Four descriptions of steel shot, of the following weights, as nearly as manufacturing limits will allow:—spherical 35·5 lbs., elongated 71 lbs., elongated 106·5 lbs., elongated 64 lbs.‡,—all to be hemispherical-headed, and of 6·22 inches diameter.

*Charges.*—To be so arranged that each projectile may strike with the same "work" stored up in it.

*Iron Plates.*—Best rolled iron, 5½ inches thick, placed vertically at a distance of 100 yards, and unbacked.

The programme for the second point was as follows:—

*Guns.*—6·3-inch M L rifled gun of 140 cwt.; 7-inch M L rifled gun of 134 cwt.; 100-pounder smooth-bore gun of 6¼ tons (9-inch).

*Projectiles*§.—For 6·3-inch gun, same as detailed in the first programme; for 7-inch gun, elongated steel shot of 100 lbs. weight and 6·92 inches diameter; for 100-pounder gun, spherical steel shot of 104 lbs. and 8·87 inches diameter.

*Charges.*—To be so arranged that each projectile may strike with a "work" proportional to its diameter, taking the 6·3-inch as the standard.

*Iron plates.*—Best rolled iron 5½ inches thick, placed at a distance of 100 yards, and unbacked.

* The experiments hitherto carried out have given us a fair practical knowledge of the conditions to be fulfilled in order that complete penetration through iron defences may be effected.

We can predict, with a very close approximation to the truth, whether a given projectile striking with a given velocity, will or will not perforate a given iron structure; but supposing it not to be able to perforate it, we cannot say how far it will *indent* it, and it is submitted that this is of little consequence.

† The gun used in the first series of experiments against 5·5-inch plates was the experimental 6·3-inch gun of 140 cwt., length of bore 126 inches. This enabled the necessary ·h velocity to be obtained.

Same weight as service-shot.

Elongated projectiles were all hemispherical-headed.

*Determination of the charges.*—The charges were determined with the aid of Navez's apparatus, by which the velocity of each projectile was observed at the distance of 100 yards from the muzzle. Cast-iron shot were supplied for this experiment, their weight being the same as the steel shot. The spherical projectiles were shells weighted up with lead.

The following Table shows the velocity which it was necessary each projectile should have in order that the conditions might be fulfilled:—

TABLE I.—Showing the necessary velocities and charges determined by experiment. 5·5-inch plates. Projectile, solid steel hemispherical-headed shot.

| Gun. | No. of experiment. | Charge determined by experiment. | Projectile. Mean weight. | Projectile. Mean diameter. | Necessary velocity at 100 yards. | "Work" on impact at 100 yards. | Remarks. |
|---|---|---|---|---|---|---|---|
| | | lbs. | lbs. | inches. | feet. | foot-tons. | |
| 6·3-inch M L rifle gun ... | 1 | 15·848 | 35·56 | 6·22 | 1917 | 906·2 | |
| | 2 | 12·000 | 71·12 | 6·22 | 1355 | 906·2 | |
| | 3 | 11·219 | 106·68 | 6·22 | 1107 | 906·2 | |
| | 4 | 13·875 | 35.56 | 6·22 | 1823 | 819·3 | To compare with 7" B L gun*. |
| | 5 | 10·500 | 71·12 | 6·22 | 1271 | 796·2 | To compare with No. 9. |
| | 6 | 9·812 | 106·68 | 6·22 | 994 | 731·5 | To compare with 68-pounder*. |
| 7-inch M L rifle gun ... | 7 | 13·500 | 100·00 | 6·92 | 1130 | 885·8 | To compare with No. 9. |
| | 8 | 11·625 | 100·00 | 6·92 | 1022 | 724·8 | To compare with No. 10. |
| 100-pr. M L smooth-bore gun (9-inch) | 9 | 15·374 | 104·00 | 8·87 | 1254 | 1135·4 | To compare with Nos. 5 and 7. |
| | 10 | 11·125 | 104·00 | 8·87 | 1135 | 929·0 | To compare with No. 8. |

The necessary charges having been thus previously ascertained, the guns were placed in battery at 100 yards from a row of 5½-inch iron plates firmly fixed by upright supports, but unbacked†.

The actual velocity of each round was observed at a short distance in front of the plate, and the striking-velocity determined by calculation.

The following Table (p. 406) gives the results.

It appears that the striking-velocities of the steel shot varied slightly from those previously determined and detailed in Table I. above. This slight difference is due to minute variations in the weights and diameters of the projectiles, and atmospheric influences, errors which it is quite impossible to guard against. Such differences, however, are of no practical importance whatever.

* Previous experiments had been made with these guns.

† The guns were fired directly at the plates; that is to say, the plane in which the shot moved was perpendicular to the face of the plates.

TABLE II.—Abstract showing the results of the experiments carried out at Shoeburyness, 22nd March, 1865, against 5·5-inch unbacked plates. 1000 to 1010 show effect of equality of *vis viva* where V and W vary. In the last three rounds the effects are not comparable:—

| | ins. | |
|---|---|---|
| 35-lb. shot, spherical, length | 6·220 | hemispherical-headed. |
| 63-lb. shot, elongated, length | 8·500 | |
| 70-lb. shot, elongated, length | 9·315 | |
| 106-lb. shot, elongated, length | 13·458 | |

| Photographic number of round. | Charge. | Weight of projectile. | Velocity on impact. | Approximate $\frac{Wv^2}{2g}$ in foot-tons on impact. | Effects with steel projectiles of 6·22-inch diameter, fired from the 6·3-inch gun of 140 cwt., R., Expl. No. 275. |
|---|---|---|---|---|---|
| | lbs. | lbs. | feet. | | |
| 1000 | 15·848 | 35·875 | 1920 | 917·0 | Clean hole through plate, and 3 ft. 2 ins. into earth. |
| 1003 | 15·848 | 35·562 | 1925 | 913·8 | Clean hole through plate, and stopped by a balk of timber. |
| 1001 | 12·000 | 63·687 | 1417 | 886·7 | Clean hole through plate, and 3 ft. 6 ins. into earth. |
| 1004 | 12·000 | 70·937 | 1345 | 889·8 | Struck left edge of plate and broke in three pieces. |
| 1006 | 12·000 | 71·250 | 1346 | 895·1 | Clean hole through plate, and 5 ft. 6 ins. into earth*. |
| 1002 | 11·219 | 106·625 | 1110 | 911·0 | Clean hole through plate, and 3 ft. 3 ins. into earth. |
| 1007 | 11·219 | 106·812 | 1112 | 915·8 | Clean hole through plate, depth in earth not known. |
| 1008 | 13·875 | 35·562 | 1829 | 824·9 | Clean hole through plate, about 1½ ft. into earth. |
| 1009 | 10·500 | 70·875 | 1270 | 792·7 | Stuck in plate; base projects 3½ ins. from face of plate; slight star in rear, outer lamina off plate. |
| 1010 | 9·812 | 106·562 | 996 | 733·1 | Stuck in plate; base projects 7 ins. from face of plate; part of shot showing through in rear. |

If we consider this Table, it appears that numbers 1000, 1001, 1002, 1003, 1006, and 1007 all passed through the plates, and to about the same depth in the earth behind, which is a rough indication of their possessing the same remaining "work." These effects were produced by projectiles of various weights, the difference being very considerable; but the velocities were so arranged that the expression $Wv^2$ was nearly a constant. Thus No. 1000, consisting of a spherical shot of 35·9 lbs., with velocity of 1920 feet, and "work" of 917 foot-tons passed through the plate, and subsequently penetrated 3 feet 2 inches into earth. No. 1002, consisting of an elongated steel shot of 106·6 lbs., with velocity of 1110 feet, and "work" 911 foot-tons, also penetrated the plate, and subsequently 3 feet 3 inches into earth. The difference between W and $v$ in this instance is very marked, and the "work" done is the same.

* Earth loosened by a former shot.

TABLE III. To determine the relative resistances of a plate to penetration by two shots of similar form of head and striking with *vis viva* proportional to their different diameters. Solid steel shot, hemispherical-headed.

| Photographic number of round. | Gun. | Charge. | Projectile. | | Velocity on impact. | Approximate $\frac{Wv^2}{2g}$ in foot-tons on impact. | $\frac{Wv^7}{2g}$ as proportional to diameter. | Effects. |
|---|---|---|---|---|---|---|---|---|
| | | | Weight. | Diameter. | | | | |
| | | lbs. | lbs. | ins. | feet. | | | |
| 1011 | 100-pounder smooth-bore | 15·437 | 104·125 | 8·87 | 1254 | 1135·4 | 1135·4 | Clean hole through plate, and 3 ft. 3 ins. into earth. |
| 1009 | 6·3-inch M L ..... | 10·500 | 70·875 | 6·22 | 1270 | 792·7 | 796·2 | Stuck in plate, base projects 3½ ins. from face of plate (see Table II.). Nose was nearly through. |
| 1027 | 100-pounder smooth-bore | 11·125 | 104·000 | 8·87 | 1135 | 929·0 | 929·0 | Shot rebounded, indent 3·25 ins. deep, plate bulged and cracked in rear, over an area of 1 ft. 2 ins. by 1 ft. Same plate as 1002, 1003, 1009. |
| 1012 | 7-inch M L, No. 217 ... | 11·625 | 100·312 | 6·92 | 1004 | 701·1 | 724·8 | Shot rebounded, indent 3·655 ins. deep, 7·33 ins. diameter. Plate cracked in rear. Shot much cracked. |
| 1013 | 7-inch M L, No. 217 ... | 11·625 | 100·125 | 6·92 | 1012 | 711·0 | 724·8 | Shot rebounded, indent 4 ins. deep, 7·1 ins. diameter. Plate cracked in rear. |
| 1011 | 100-pounder smooth-bore | 15·437 | 104·125 | 8·87 | 1254 | 1135·4 | 1135·4 | Clean hole through plate, and 3 ft. 3 ins. into earth. |
| 1026 | 7-inch M L, No. 217 ... | 13·500 | 100·312 | 6·92 | 1131 | 889·7 | 885·8 | Clean hole through plate, shot struck and broke support of wood 1 ft. square, and fell in rear. Same plate as 1000, 1004, 1010. |
| 1008 | 7-inch B L ..... | 12·000 | 110·000 | 6·88 | 1090 | 906·2 | 906·2 | Just penetrated the plate, 2 ft. into earth. Brown's steel. |
| 765 | 6·3-inch M L ..... | 13·875 | 35·562 | 6·22 | 1829 | 824·9 | 819·3 | Just *penetrated* the plate, 1½ ft. into loose earth. See Table II. |
| 1009 | 6·3-inch M L ..... | 10·500 | 70·875 | 6·22 | 1270 | 792·7 | 819·3 | See above. Did not penetrate, base 3½ ins. out. |
| 908 | 68-pounder smooth-bore | 16·000 | 72·000 | 7·91 | 1365 | 930·2 | 930·2 | Indent 2·8 ins., plate cracked behind. Firth steel. *Minute* 14,082. |
| 1010 | 6·3-inch M L ..... | 9·812 | 106·562 | 6·22 | 996 | 733·1 | 731·5 | Stuck in plate. See Table II. |

If we examine Table III., it appears that penetration* varies nearly in the inverse ratio of the diameter. The only round which does not bear this out is No. 1009; and in this case the fault may have been in the steel of which the projectile was composed. Thus Nos. 1008 and 765 agree exactly; 1011 and 1026 are practically equal in effect, and Nos. 1027, 1012, and 1013 are all very similar in their effects. As before mentioned, in an experiment of such a practical description we must not look for too much theoretical harmony in the results; and when we remember that steel and iron vary so much in quality, exact results cannot be expected.

The Committee, however, determined to repeat the experiments against 4·5-inch plates, and to fire with such charges that the projectiles should strike with a force which would be merely sufficient to *just* penetrate through the plate†.

It appears from Table II., round 1008, that a 6·22 inch projectile is *just* able to penetrate a 5·5-inch plate, with a "work" on impact of about 825 foot-tons; and if we assume that the resistance of the plate varies as the square of its thickness, we shall have the following proportion to determine the "work" necessary to penetrate a 4·5-inch plate with the same projectile, viz.:—

$$5{\cdot}5^2 : 825 :: 4{\cdot}5^2 : x ;$$

and $x = 552$ foot-tons.

In order therefore to *just* penetrate a 4·5-inch wrought iron unbacked plate, a 6·22-inch solid steel hemispherical-headed shot ought to strike with a "work" represented by about 552 foot-tons; and if we take the weights of the projectiles to be approximately

35·56<br>63·87<br>71·00<br>106·62 } lbs.

the following Table gives the velocities which each of these projectiles must be moving at, in order that the "work" on impact may equal 552 foot-tons.

Table IV.—Showing the weights of hemispherical-headed steel 6·22-inch shot, with the velocity necessary to give a constant "work" of 552 foot-tons at 100 yards.

| Weight of shot. | Necessary velocity at 100 yards. | $\frac{We^2}{2g}$. | Remarks. |
|---|---|---|---|
| lbs. | feet. | foot-tons. | |
| 35·56 | 1496·5 | 552·2 | Round shot. |
| 63·87 | 1116·6 | 552·2 | |
| 71·00 | 1059·0 | 552·2 | |
| 106·62 | 864·2 | 552·2 | |

Having carried the investigation thus far, it became necessary to determine whether the assumption, that the resistance of wrought-iron plates varies as the square of their thickness, was correct,—in other words, to ascertain whether a "work" of 552 foot-tons would *just* penetrate a 4·5-inch plate

* See note ‡, p. 403.

† The results obtained by the previous experiment had proved that the "work" in some of the shot was more than sufficient to effect complete perforation; and the aim of the second experiment, against 4·5-inch plates, was to so apportion the charges that the several projectiles should be only *just* capable of getting through the plate.

with a 6·22-inch shot. This was determined in the following manner by a preliminary experiment.

The weight of the steel shot was 63·87 lbs., its diameter 6·22 inches, and the required velocity 1116·6 feet. It was found by experiment that a shot of this description would be moving with a velocity of nearly 1116·6 feet at 100 yards distance, if it were fired with a charge of 6 lbs. 11 ozs. of powder. This charge was therefore employed in round 1047 with the following results.

Shot struck 4·5-inch unbacked plate about the centre and *just* penetrated the plate, the shot rebounding 6 yards. From this result it appeared that a "work" of about 552 foot-tons was *just* capable of piercing a 4·5-inch unbacked plate, and that, practically speaking, the assumption that the resistance varies as the square of the thickness was correct.

The experiments might therefore proceed.

It appears from the above Table that when the weight of the projectile varies from 35 to 106 lbs. the velocity will vary from 1496 to 864 feet, if the "work" is required to be constant.

In order therefore to strike the 4·5-inch plates with a constant "work" of 552 foot-tons, we must so proportion the charges of powder that the several projectiles on impact may be moving with their corresponding velocities as shown by Table IV. This has been done by observing the velocity at 100 yards of a series of cast-iron projectiles of as nearly as possible the same weight as the steel shot, the cast-iron projectiles corresponding to the *spherical* steel shot being a shell brought to the proper weight by being filled with lead.

The following Table shows these charges determined by experiment:—

TABLE V.—Showing the approximate charges with which various steel hemispherical-headed shot should be fired from the 64-pounder M L gun, in order that the work may be constant at 100 yards.

| Weight of shot. | Velocity on impact. | $\frac{Wv^2}{2g}$. | Approximate charge determined by experiment. |
|---|---|---|---|
| lbs. | feet. | foot tons. | lbs. ozs. |
| 35·56 | 1496·5 | 552·2 | 8 0 |
| 63·87 | 1116·6 | 552·2 | 6 10 |
| 71·00 | 1059·0 | 552·2 | 6 10 |
| 106·62 | 864·2 | 552·2 | 6 11½ |

The charges given in the last Table are termed "*approximate*," because it would be untrue to assert that these charges would give the absolute velocities required, although they are the nearest approximation we can make, or the probability of the velocity being the required one is nearer with these charges than with any others.

The charges having thus been determined, the different projectiles were fired at the 4·5-inch unbacked plates; the velocity of each projectile was observed at a short distance in front of the plate, and the small loss of velocity due to the resistance of the air during this short distance was calculated by the most approved theory, which, although it may not give results which are *strictly* correct, is practically sufficiently near the truth when the range is small.

The following Table gives the velocities, both observed at 80 feet distance from the plates, and calculated on impact. The penetration of each shot is given in the column of remarks.

TABLE VI.—Abstract showing the results of experiments carried out against 4·5-inch unbacked plates to determine the relative penetrating effect of projectiles of the same diameter and form of head, but so varying in weight and velocity that the *vis viva* on impact was constant.

Date of experiment March 13, 1866. Brand of powder, Rifle L G. July 8, 1864. Lat. 805.

| Photographic number of round. | Number of plate. | Charge. | Weight and length of projectile. | Observed velocity at 220 feet. | Calculated velocity on impact at 300 feet. | Approximate $\frac{Wv^2}{2g}$ in foot-tons on impact. | Effects with hemispherical-headed steel projectiles of 6·22-inch diameter, fired from the service 64-pounder M L. Gun of 6·3-inch calibre. |
|---|---|---|---|---|---|---|---|
| | | lbs. | | feet. | feet. | | |
| 1047* | ... | 6·69 | 63·87 lbs. 8·42 in. | 1121·2 | 1112·2 | 547·8 | Just penetrated. Shot rebounded about 6 yards; length of shot 8·05 inches. |
| 1158 | 1 | 6·63 | 63·87 lbs. 8·42 in. | 1128·3 | 1119·3 | 554·8 | Just penetrated; broke plate behind in the usual manner; shot rebounded 4 feet; length of shot 7·92 inches; diameters of hole 6×6·25 inches. |
| 1159 | 1 | „ | 70·94 lbs. 9·3 in. | 1077·7 | ... | ... | Miss. Struck support of plate and glanced off into the earthwork. |
| 1160 | 1 | 6·09 | 106·19 lbs. 13·39 in. | 864·1 | 860·5 | 545·2 | Through plate, breaking away rear in the usual manner. Shot fell 2 feet in rear; length of shot 12·92 inches; diameters of hole 6·75×7·5 inches. |
| 1161 | 1 | 7·87 | 35·50 lbs. 6·22 in. | 1483·6 | 1460·0 | 524·7 | Stuck in plate, breaking it away behind shot almost through. |
| 1162 | 2 | 8·00 | 53·56 lbs 6·22 in. | 1506·7 | 1482·4 | 541·8 | Just penetrated; broke plate behind in the usual manner; shot rebounded 4 feet; diameter of shot 6·32 inches; diameters of hole 6·4×6·5 inches. |
| 1163 | 2 | 6·63 | 70·94 lbs. 9·3 in. | 1069·2 | ... | ... | Miss. Struck support and glanced into earthwork. |
| 1164 | 2 | „(?) | 63·81 lbs. 8·42 in. | 1107·1 | 1098·2 | 533·6 | Almost penetrated; broke away plate behind over an area of 1 foot by 1 foot. Shot rebounded 5 feet 9 inches. Indent 4·35 inches; length of shot 7·95 inches. |
| 1165 | 2 | 6·09 | 106·62 lbs. 13·39 in. | 861·3 | 857·7 | 543·9 | Stuck in plate, breaking it away at back something more than round 1164: shot almost through. |
| 1166 | 3 | „ | „ | 863·1 | 859·5 | 546·2 | Through plate. Shot turned over and entered earthwork to a depth of 1 foot; length of shot 12·96 inches. |
| 1167 | 3 | 8·00 | 35·50 lbs. 6·22 in. | 1509·2 | 1484·9 | 542·8 | Made a hole clean through, but shot remained sticking in the plate, projecting as much in rear as in front. |

If we examine this Table, it appears—

1. That all the projectiles but one struck with "work" slightly under that which was required, viz. 552 foot-tons; and that 542 tons is only just capable of piercing a 4·5-inch plate.

Thus, in most instances, the shot, *after penetration*, rebounded and fell in *front* of the plate, showing that they had expended almost their entire force in the penetration.

As 552 tons was calculated on data supplied by a shot (round 1005)

* Preliminary round.

which penetrated *and had some little force left in it*, it is to be expected that a force of 542 tons should act as it did. It appears that a reduction of 2 ozs. in the charge, and consequent diminution of "work" to 525 foot-tons was sufficient to prevent complete penetration (round 1161), although it apparently required but a small blow with a hammer to separate the piece of plate at the back of the point struck: as this effect was produced by the shot moving with the highest velocity, it is a convincing proof that with steel shot the penetration is not proportional to a higher power than the square of the velocity.

2. Round 1164 is the only anomalous round in the present series: it was supposed to be fired with exactly the same charge as round 1158; yet the penetration was inferior, and the *observed* velocity less. It is difficult to account for this except on the supposition that, through some oversight, a smaller charge was employed, or that the projectile was not quite rammed home.

3. It is clearly proved that plate 2 was of somewhat better quality than plates 1 and 3. The fracture showed a better weld; and this is evident by the increased resistance it offered to the projectiles—round 1165 especially.

It is difficult to guard against this cause of error, which is one of the many that beset this question.

From these experiments, the following practical conclusions may be drawn when the *projectiles* are *fired* direct.

1. An unbacked wrought-iron plate will be perforated with equal facility by solid steel shot of a similar form of head, and having the same diameter, provided they have the same *vis viva* on impact; and it is immaterial whether this *vis viva* be the result of a heavy shot and low velocity, or a light shot and a high velocity.

2. An unbacked iron plate will be penetrated by solid steel shot of the same form of head but different diameters, provided their striking *vis viva* varies as the diameter nearly—that is as the circumference of the shot.

3. That the resistance of unbacked wrought-iron plates, to absolute penetration by solid steel shot of similar form and equal diameter, varies as the square of their thickness nearly *, up to 5½ inches.

4. These experiments have proved that although, in the case of *cast iron*, a light projectile moving with a high velocity will indent iron plates to a greater depth than a heavier projectile with a low velocity but equal "work," it is not as necessary that there should be a high velocity when the projectiles are of a hard material, such as *steel* and *chilled iron*; and this result will be much in favour of rifled guns, by enabling them to prove effective with comparatively moderate charges.

If we wish to put these results in an algebraic form, we shall have, taking the units as the pound and the foot,

$$\frac{Wv^2}{2g} = 2\pi R k b^3 \dagger, \quad \ldots \ldots \ldots \ldots \quad (1)$$

* This is only true when the plates are of the best quality. It is well known that it is easier to make a thin than a thick plate, and that the latter is liable to imperfect welding in the process of rolling. The manufacture of armour-plates has, however, been so much improved of late, that it is practically allowable to assume that their resistance varies as the square of their thickness, within ordinary limits.

† The above might be put as follows: foot-tons $= kb^2d$, where $d$ is the diameter of the projectile. The circumference, however, is preferred as better representing the portion of iron actually sheared.

where

W = weight of shot in lbs.
$v$ = velocity on impact in feet.
$g$ = gravity.
2R = diameter of shot in feet.
$b$ = thickness of unbacked plate in feet.
$k$ = a coefficient depending on the nature of the wrought iron in the plate, and the nature and form of the head of shot.

The shot is supposed to be of the best quality of steel, and the plate of the best quality of wrought iron.

Solving the equation (1) for $b$, we have

$$b = v\sqrt{\frac{W}{4\pi R g k}}, \quad \ldots\ldots\ldots\ldots \quad (2)$$

and for $k$,

$$k = \frac{W v^2}{4\pi R g b^2}. \quad \ldots\ldots\ldots\ldots \quad (3)$$

In order to determine $k$, we can form a series of equations of the following conditions:—

$$4\pi R_1 g b^2 k - W_1 v_1^2 = 0,$$
$$4\pi R_2 g b^2 k - W_2 v_2^2 = 0,$$
$$4\pi R_3 g b^2 k - W_3 v_3^2 = 0,$$
$$\&c. \quad \&c. \quad \&c.$$

Substituting the experimental values of the different quantities, and eliminating $k$, we find that for hemispherical-headed shot

$$k = 5357200.$$

Having thus determined the value of $k$, we can calculate the "work" necessary to penetrate any unbacked plate of given thickness.

Thus, let us determine the "work" required to *just* penetrate a 5·5-inch plate with a hemispherical-headed steel shot of 6·22 inches diameter.

Here we have

$$R = 3{\cdot}11 \text{ inches} = 0{\cdot}25917 \text{ feet},$$
$$b = 5{\cdot}5 \text{ inches} = 0{\cdot}45833 \text{ feet},$$
$$k = 5357200;$$

and substituting these values in equation (1), we find that

$$\frac{W v^2}{2g} = 1832522 \text{ lbs.}$$
$$= 818 \text{ foot-tons.}$$

We see that round 1008, consisting of a spherical shot of 35·56 lbs. and 6·22 inches diameter, moving with a velocity of 1829 feet, and consequent "work" of 825 foot-tons, just penetrated a 5·5-inch plate. This "work" is practically the same as that given in the above example, as a difference of 5 ozs. in the weight of the shot would have reduced its work to 818 foot-tons.

By means of the foregoing equations, we can determine most of the effects against unbacked plates; and the following examples are given in proof.

*Example* I.—What thickness of unbacked wrought-iron plate will withstand the impact of a solid hemispherical-headed steel shot of 115 lbs. weight, and 6·92 inches diameter, fired with a charge of 22 lbs. from the 7-inch ML rifled Woolwich gun at 1000 yards, remaining velocity at that distance being 1260 feet?

Here we have from equation (2),

$$b = b\sqrt{\frac{W}{4\pi R g k}};$$

and substituting the values above, we find

$$b = 6{\cdot}486 \text{ inches.}$$

The thickness of plate to resist this shot ought therefore to be more than 6·5 inches.

*Example* II.—The 68-pounder smooth-bore gun is fired with a spherical steel shot of 72·0 lbs. weight and 7·91 inches diameter, the striking-velocity at 200 yards being 1365 feet; what thickness of unbacked plate will it penetrate?

Here we have, as before,

$$b = v\sqrt{\frac{W}{4\pi R g k}};$$

and substituting the above values,

$$b = 5{\cdot}2 \text{ inches.}$$

Round 906, fired with the above charge, failed to perforate a 5·5-inch plate, although it indented it to a depth of 2·8 inches, and cracked off the plate behind. We find, however, that the 68-pounder penetrated a 4·75-inch plate on the "Small-plate" target (round 842), and a 5-inch plate (round 960).

*Example* III.—The 13·3-inch gun of 22 tons was fired at an 11-inch plate with a spherical steel shot of 344·4 lbs. weight and 13·24 inches diameter; charge 90 lbs., the striking-velocity being 1574 feet at 200 yards: ought it to have penetrated the plate? Now the thickness of unbacked plate which this shot will penetrate can be found from equation (2),

$$b = v\sqrt{\frac{W}{4\pi R g k}};$$

and substituting the above values, we find

$$b = 10{\cdot}14 \text{ inches.}$$

Round 704, minute 11,287 shows that a shot of the above nature indented an 11-inch unbacked plate to a depth of 4·9 inches and broke the plate in two.

*Example* IV.—The embrasures of a fort are protected with unbacked wrought iron plates of 8 inches thickness, with what velocity should a 250-lb. hemispherical-headed rifle shot of 8·92 inches diameter strike so as to ensure penetion? Here we have, from equation (1),

$$v = b\sqrt{\frac{4\pi R g k}{W}};$$

and substituting the above values, we find

$$v = 1197 \text{ feet.}$$

From this it follows that if the 9-inch rifled Woolwich gun was fired with its service-charge of 43 lbs. and a 250-lb. steel shot it would penetrate an unbacked 8-inch plate at about 1200 yards.

*Example* V.—The 12-pounder B L Armstrong gun is fired with an elongated steel shot of 12·60 lbs. weight and 2·90 inches diameter, charge 1·5 lb., velocity 10,807 feet at 200 yards *; will this projectile penetrate a 3-inch plate

* These velocities were all observed.

[illegible]

[illegible] same. Here we have, from equation 2,

$$\frac{V}{\quad} = \text{[illegible] foot-tons.}$$

[illegible] circumference: and we also find from the same equation that it requires [illegible] foot-tons per inch of the shot's circumference to penetrate a ½-inch plate.

The [illegible] will not penetrate, although it would be very [illegible] The [illegible] are on pp. [illegible] and 363.

[illegible]—We have test some steel shells of 115 lbs. weight and 6·92 [illegible] from the 7-inch Woolwich gun, with 22 lbs. charge, [illegible] of about 1350 feet. We have a target, [illegible] of steel projectiles fired from heavy guns. [illegible] plates backed by about 21 inches of wood. Will [illegible] ?

[illegible] the following conditions ought [illegible] the 7-inch plate which protects the target should not be of [illegible] that which the shell would be capable of penetrating [illegible] assuming that the shell of steel would have as great a [illegible] as it would have the same form and weight, the thickness of the plate [illegible] as will admit of the shot getting its nose into the backing. This condition is self-evident, for if we increase the thickness of the protecting plate beyond the power of the shot, it is manifest that the only result of firing a shot at it would be an indent, and that it would not signify whether there was powder in the shell or not.

From equation 2,

$$b = v\sqrt{\frac{W}{4\pi R g k^2}}$$

we can find the maximum thickness of plate which a shot of the same form as the above shell will penetrate. Substituting the values, we find

$$b = 7\cdot[illegible] \text{ inches.}$$

From this we see that a target fixed with 5-inch plates is unsuitable for testing steels from the 7-inch Woolwich gun with the above charge, and, moreover, that something less than 7 inches should be the maximum thickness of plate of a target placed for such a purpose at 300 yards.

We could further demonstrate that the 5-inch target would do very well for larger projectiles, such, for instance, as those fired from the 9-inch Woolwich gun of 12 tons.

*Example* VII.—The wall piece is fired with a cylindrical steel shot of 0·344 lb. weight and 0·87 inch diameter at a ¾-inch plate, velocity on impact being 1141 feet; ought it to penetrate it? and will it also penetrate a 1-inch plate?

Here we have

$$b = v\sqrt{\frac{W}{4\pi R g k^2}};$$

and substituting the above values, we find

$$b = 0\cdot906 \text{ inch.}$$

The shot would therefore penetrate a ¾-inch plate, but not one of 1 inch. That this is correct we find from the Tables.

*Example* VIII.—We wish to *just* penetrate a 5·5-inch plate with a solid hemispherical-headed shot of 6·88 inches diameter, fired from the 7-inch

breech-loading gun; with what "work" should the projectile strike in order to accomplish this?

Here we have by equation (1)

$$\frac{Wv^2}{2g} = 2\pi Rk\, b^2;$$

and substituting the values, we find that the necessary "work" or

$$\frac{Wv^2}{2g} = 905 \text{ foot-tons.}$$

Experiment gives 906 foot-tons as the "work" necessary.

It is unnecessary to give further examples of penetration through unbacked plates; the subject of backed plates will be further considered when the results of experiments against various targets representing existing iron-clad ships have been reviewed.

*On Oblique Fire.*—We have hitherto considered the fire as being direct; that is to say, the plate has been supposed to have been placed perpendicular to the ground and the gun to have been so directed that the plane in which the shot * moved was perpendicular to the face of the plate, or nearly so.

Let us suppose, however, that the plate has been set at an angle, or that the gun fires obliquely at an upright plate. The shot has then a tendency to glance off and continue its motion in a new direction, and we shall have the following proportion, viz.:—

The force with which the shot, acting obliquely, will strike is to that with which it would strike if acting directly as the sine of the angle of incidence is to unity†.

Equation (1) will therefore become

$$\frac{Wv^2}{2g} = \frac{2\pi Rkb^2}{\sin^2\theta}, \quad \ldots\ldots\ldots \quad (4)$$

and (2),

$$b = v \sin\theta \sqrt{\frac{W}{4\pi Rgk}}. \quad \ldots\ldots\ldots \quad (5)$$

It appears from this that the resistance of the plate increases as the value of $\theta$ diminishes.

We have already shown that a 4·5-inch unbacked plate, when fired at direct, requires a force represented by 28 foot-tons per inch of shot's circumference to ensure penetration.

Let us suppose, however, that we place the plate in such a position that it makes an angle of 38° with the ground. From equation (4) we find that the force required to penetrate it in this position amounts to 1445 foot-tons for a shot of 6·22 inches diameter, or 73·9 foot-tons per inch of the shot's circumference. We may expect, therefore, that a less force will not penetrate a 4·5-inch unbacked plate placed at an angle of 38°.

An experiment of this nature was actually tried by the Armstrong and Whitworth Committee; they caused 4·5-inch plates to be set up at an angle of 52° with the vertical, and fired at them from 200 yards distance with the competitive Armstrong and Whitworth guns.

It appears that the projectiles were solid steel shot of 70 lbs. weight and 6·34 inches diameter, that they struck with a "work" of 1049 foot-tons or

* The shot is assumed to have no lateral deviation.

† That is, the shot striking in a slanting direction may be supposed to have opposed to it a plate of a thickness equal to the diagonal formed by the line of direction.

52·7 tons per inch of shot's circumference, and that they *failed to pass through*, although the plate was cracked and opened at the back.

The Special Committee on Iron carried out some experiments with a wall-piece, firing steel flat-headed shot at $\frac{3}{4}$-inch unbacked plates placed at various angles.

The wall-piece is able to pierce this plate in an upright position, but it failed to do so in any case when the plate was at an angle. It is a pity this experiment was not continued with different thicknesses of plates, as the present results do not afford sufficient data.

The results of experiments with this wall-piece have proved that much valuable information may be obtained at a comparatively trifling expense.

Although it would be of advantage to carry out further experiments on the effect of fire directed obliquely against iron defences, still we have sufficient evidence to prove that the power of resistance is much increased by placing the target at an angle. This result is in favour of turrets or cupolas for sea and land defences, as there is a great probability that such structures will be struck obliquely.

It is also in favour of protecting guns by iron shields placed at a slope, and not upright.

*The effect of Cast-Iron Projectiles as compared with Steel of the same size and form.*

The difference between the effects of cast iron and steel shot is most marked. The latter material is the nearest approach to perfect hardness and cohesion which we have been able to procure, and the amount of work expended on the shot is less with steel than any other known material. With ordinary cast iron a very large amount of "work" is expended in breaking up the projectile, and hurling the fragments in all directions. When steel shot are manufactured in the best possible manner, very little "work" is expended on the projectile; and in one instance a 12-pounder Whitworth steel shot was of such perfect material that, after passing through $2\frac{1}{2}$ inches of solid iron, its temperature was apparently unaltered, and its form so slightly changed that it might have been fired from the gun a second time. Several experiments have been instituted with a view of ascertaining the amount of work lost by the breaking up of cast iron, alteration of form of steel shot, &c.

Sir William Armstrong endeavoured to treat the question by an application of the dynamic theory of heat. Having fired projectiles of various materials against iron plates, he attempted to measure the quantity of heat generated by the concussion.

This method was very ingenious, but most difficult to carry out; and the results of such trials can only be looked upon as approximate.

The conclusions drawn by Sir William Armstrong from his experiments were as follows:—

1st. With hard and well-tempered steel shot the "work" expended on the projectile was about one-tenth of the total work in the shot on impact.

2nd. With soft steel the "work" expended on the projectile was about two-tenths of the whole "work."

3rd. With soft wrought iron it amounted to nearly one-half.

These experiments are alluded to in the memorandum on this subject by Professor Pole, F.R.S., published in the Report of the Special Committee on Iron, 1862, p. 30.

If we examine the results of the various experiments in which cast-iron projectiles were used in comparison with, or under the same circumstances as, steel

shot, we shall find that in almost every instance where the projectiles were moving at a velocity not exceeding 1200 feet, the cast-iron shot may be said to require about 2½ times the "work" necessary to effect the same amount of perforation with steel shot. When, however, the velocity of the cast-iron shot is very high, this proportion is reduced to about 1·7. This latter result is due to the influence which the element velocity has in the penetration of cast-iron shot. If we suppose two cast-iron projectiles to be of the same form of head and diameter, and to be animated with the same amount of energy or "work," consisting in one case of a heavy shot and low velocity, and in the other of a light shot and high velocity, the effect of these projectiles will be very different.

The damage in the case of the low velocity will be spread over a larger surface, and the absolute indent will be small; while in the case of the high velocity the effect will be confined to the immediate neighbourhood of the point of impact, and the result will be a deep indent. This result with cast-iron shot is so well known that it seems almost needless to allude to it; we may, however, select one or two examples for record.

Thus the 'Bellerophon' target was struck by two projectiles fired from the 10·5-inch gun (rounds 717–719). The first consisted of a spherical shot of 150 lbs., moving with a velocity of 1547 feet, and a consequent "work" of 76 foot-tons per inch of shot's circumference; the second, of an elongated shot of 308 lbs., moving with a velocity of 1090 feet, and consequent "work" of 77 foot-tons per inch of shot's circumference.

In the first instance the indent was 5 inches, and the damage was confined to the point struck. In the second instance the indent was 1·6 inch, but the plate was cracked and bulged over a large area.

The following Table shows the absolute thickness of plate which can be penetrated by cast-iron shot fired from various guns with service-charges: the guns were at a distance of 100 yards from the plates, with the exception of the 68-pounder, which was at 200 yards (see Appendix, Table X.):—

TABLE VII.—Showing the difference between the effects produced by cast-iron and steel shot, when fired at iron plates.

| Thickness of plate. | Foot-tons per inch of shot's circumference required for absolute penetration. | | Difference. | Proportional excess for cast-iron shot. | Remarks. |
|---|---|---|---|---|---|
| | Cast-iron shot*. | Steel shot†. | | | |
| inches. | | | | | From results with |
| 1·286 | 5·63 | 2·29 | 3·34 | 2·517 | 6-pr. B L rifled gun. |
| 1·803 | 11·05 | 4·49 | 6·56 | 2·461 | 12 " " |
| 2·350 | 18·32 | 7·64 | 10·68 | 2·398 | 20 " " |
| 2·820 | 25·32 | 11·00 | 14·32 | 2·302 | 40 " " |
| 3·850 | 35·30‡ | 20·50 | 14·80 | 1·722 | 68-pr. smooth-bore. |

If we compare the results given by this Table with the effect of steel projectiles, it will appear that the cast-iron shot requires about 2½ times the "work" of the steel shot to effect the same penetration, except where the velocity of the cast-iron shot is large. This Table has been drawn up with a view of showing the difference in effect of cast iron in comparison with steel shot.

* From actual experiment on plates of various thicknesses.

† Deduced from experiments with various guns at plates of 5·5, 4·5, 3·5, 3·0, and 2·5 inches thickness.

‡ Shot moving at a high velocity.

*On the Material and Proper Form of Projectiles for the Penetration of Iron Defences.*

We have already seen that it is almost useless to fire cast-iron projectiles against iron defences if *penetration* is required; it will therefore be necessary to use a material which will effect our purpose at a moderate cost.

Steel is a most expensive material for shot; and as we have proved that Palliser's chilled iron is almost, if not entirely, as good as steel, all our projectiles for battering-purposes will most probably be made of this material. The proper form of front or head to be given to hardened projectiles for use against iron plates is a subject of much importance. Various forms have been proposed for this purpose.

Mr. Whitworth relies on the flat-headed form, while most of Sir Wm. Armstrong's projectiles have been round-headed or hemispherical; Major Palliser has used elliptical heads, and lately, in the projectiles for the 13-inch gun, a sharp-pointed form. The flat-headed form is supposed to be right, because it is generally used as the form of a punch. But although a flat-headed punch, when used with a die, will make a nice *clean* hole in a plate of iron, it by no means follows that a sharp-pointed or "centre" punch will not make a *rugged* hole of equal size, with the same, if not greater ease.

The manufacturer uses the flat-headed punch in order that he may be enabled to cut out a *clean* hole; but the artilleryman does not care what shaped hole he makes so as *it is made*; and if he has a preference at all, it is for a rugged hole which it is difficult to mend or plug up.

We find in practice that the pointed form is the best for the artilleryman, particularly when the iron plates are backed by wood.

A consideration of the result of firing at a backed target will make this evident.

The flat-headed or round-headed shot punches out a piece of the armour plate, and drives it into the backing; the shot, however, has no means of ridding itself of this piece of armour plate, and consequently it has to *push it in front of it through the backing.* Thus in targets penetrated by flat-headed or round-headed shot, we invariably find that the piece of armour plate has passed through the target along with the shot. It is needless to remark that this piece of jagged armour plate must greatly increase the resistance which the shot meets in passing through the backing.

When, however, the shot is of the form of a pointed ogival, the results of its action are far different: this projectile cuts through the armour plate, or rather tears it through, and the plate is bent back and forced into the backing round the edge of the hole. The shot thus passes through the backing without carrying any jagged armour in front of it*.

A very good illustration of this was obtained in the practice with the 13-inch M L gun at the 'Hercules' target; and the photographs of the target taken when the plates were removed show the effect in the most marked manner.

Round 1141: a steel round-headed shot penetrated the lower or 8-inch plate of the 'Hercules,' forcing the piece of plate against the backing. On the plate being removed, this piece of iron was found exactly as the shot had punched it out, and endeavoured to force it forward. The total penetration or indent was about 13 inches.

Round 1145: a chilled iron pointed-headed shot also struck the 8-inch

* In practice with ogival-headed shot we seldom, if ever, find that any part of the armour plate has passed through the target with the projectile.

plate and tore through it, bending the edges of the plate back, and forcing them laterally into the backing. The penetration in this case was 22 inches; and if the shot had been a perfect casting it would probably have had a greater effect.

We see also from Table XII., in the Appendix, how much greater penetration was obtained by a steel shell with a solid head in the form of a pointed ogival, than where this form was not used.

There is another disadvantage which the blunt-headed form labours under, viz. the tendency to "set up" or bulge at the head; and this result is often very marked. A pointed head, on the contrary, does not "set up" to anything like the same extent, and almost all those which have been fired have preserved their points intact after passing through the plates.

On the whole, it may be said that in the case where the projectile ought to be capable of piercing the plate or target there is little difference between the effects of a flat head and a hemispherical head; but when the target is beyond the power of the shot the hemispherical head makes the deepest indent. This is clearly shown in the case of the experiments with a wall-piece at a 4·5-inch unbacked plate, and 12-pounder Armstrong and Whitworth guns, at the Scott-Russell target. In every case where the target could not be penetrated, the round gave a deeper indent than the flat head.

The Tables in the Appendix give the results of some late experiments, which clearly show the great superiority of the pointed head.

In these experiments, both steel and Palliser's chilled shot were used. All the projectiles were fired from the same gun, under the same circumstances, the velocity of each round being observed. The targets consisted of a strong structure, representing the side of an iron-clad vessel protected by solid plates of 6 inches thickness, backed by 18 inches of compact teak, an iron skin of two half-inch plates, the usual iron ribs, &c. A second target of unbacked 4·5-inch plates, inclined at an angle of 38° with the ground, was erected at the same distance.

The projectiles were of a mean weight of 115 lbs., and of the following forms of head, viz.:—

*For Palliser's Chilled Shot.*

1. Ogival, head struck with a radius of 1 diameter, and brought to a point.
2. Belgian form, head struck with a radius of 1·47 diameter, and pointed in the shape of a cone.
3. Elliptical, the height of the ellipse being equal to the diameter of the projectile.

*For Steel Shot.*

1. Hemispherical.
2. Ogival, head struck with a radius of 1 diameter, and brought to a point. See Table XI., in the Appendix, round 1186 to 1201.

From this it appears—

1st. That hemispherical-headed steel shot, striking the box target with a "work" of 68 tons per inch of shot's circumference failed to penetrate completely: this result might be expected, as from calculation it would require about 82 tons per inch of circumference to send a hemispherical-headed shot completely through such a structure.

2nd. That ogival-headed steel shot, the head being brought to a point, striking the above target with a "work" of 68 tons per inch of shot's circumference, penetrated completely, with some remaining force left.

3rd. That pointed chilled shot, striking the above target with a "work" of

66 tons per inch of shot's circumference, penetrated completely, and were fully equal to the steel.

4th. That elliptical or blunt-headed chilled shot, striking the above target with a "work" of 66 tons per inch of shot's circumference, failed to penetrate completely, the indent being about equal to that made by the hemispherical-headed steel shot.

5th. That ogival-pointed chilled shot striking the 4·5-inch unbacked plates, inclined at angle of 38° with the ground, with a "work" of 66 tons per inch of shot's circumference, penetrated completely.

6th. That the same shot with the Belgian coned head failed to penetrate.

7th. That it would require a "work" of above 70 tons per inch of shot's circumference to send a hemispherical-headed steel shot completely through 4·5-inch unbacked wrought-iron plates, inclined at an angle of 38° with the ground. Such a structure therefore presents a greater obstacle to complete perforation than the 'Warrior' target if fired at direct.

Sufficient experiments have not yet been made with pointed shot to enable us to determine the value of $k$ for this form of projectile with any great exactness.

It is probable, however, that $k$ for pointed shot will be found to be about four-fifths of that for hemispherical-headed projectiles, when the target is backed, or

$$k' = \tfrac{4}{5}\, k.$$
$$k' = \tfrac{4}{5}\, 5357200.$$
$$k' = 4285760.$$

### *Spherical* versus *Elongated Projectiles.*

The experiments against iron-plated targets have clearly demonstrated the immense superiority of elongated over spherical projectiles, when the shot or shell are made of a hardened material. Elongated projectiles have been found to be less liable to alter their shape on impact; and the cylindrical form is much better adapted for steel shells, which as spherical would be almost worthless. The best form of steel shell known at present is the steel *solid-headed* shell, the head being ogival and moveable, so as to offer the least resistance to the action of the bursting charge in the forward direction.

The chief characteristics of this projectile are:—its solid pointed head, which penetrates or punches a hole in the armour, and so permits the powder to explode in the backing*; and the construction of the head which renders it very strong when acted on by a force from the outside, but weak when subject to pressure from within; it is thus easy for the bursting charge to blow the head forward through the backing and inner skin.

The form of this projectile is also well adapted for the use of gun-cotton as a bursting charge, the cotton being made up in the improved manner, viz. disks of pulp. These shells having been first proposed by Captain H. J. Anderson, R.A., are known as the "Alderson shell;" and Table XIII. (in the Appendix) shows what success attended their use (rounds 1048–1050).

It is believed that Sir William Armstrong was the first to point out the advantage to be gained by causing the powder to act in a forward direction; and the steel shells known as the "Armstrong pattern" are thus made. All these shells, however, are furnished with hollow cast-iron heads or caps, and their penetration is inferior to the shells with solid steel heads.

* See R. A. Institution Proceedings, vol. iii. page 71, line 21.

*On the Penetration into Unbacked Plates.*

We have hitherto considered the effects due to absolute penetration or *perforation*, that is, when a clean hole is made through the iron plate. Let us now examine the results of various experiments where the effect was to bend and indent the plate in consequence of the force not being sufficient to perforate it.

The Tables in the Appendix give the results of various experiments at unbacked plates.

From these Tables it appears that, when the shot is unable to perforate, the effects are very variable and difficult to compute.

Thus the total effect or "work done" by round 986 was made up of the following items:—

1st. Indent 2·3 inches.

2nd. "Work" expended in cracking indent.

3rd. "Work" in cracking and bulging rear of plate.

4th. "Work" in cracking the head of, and "setting up" the shot from 7·4 inches to 6·74 inches.

Again, we have, round 993, fired under the same circumstances:—

1st. Indent 2·2 inches.

2nd. "Work" expended in twisting the shot, cracking its head, and reducing its length from 7·4 to 6·5 inches.

Here no "work" was expended in cracking the indent or the back of the plate, but, on the other hand, the shot was more distorted in form, and more reduced in length.

It would be difficult to reduce such results to any law, unless we were possessed of data furnished by a number of carefully conducted experiments made with shot of the same form and quality, and plates of equal strength.

It is submitted, however, that the knowledge of how far a shot will penetrate *into* an iron plate is of little practical value. We can determine with a close degree of approximation whether it will penetrate *through* the plate or not; and that is the chief point. It is, however, interesting to observe the difference between the way in which the work is done in the two cases, viz. when the plate can be perforated, and when it cannot.

Thus round 986, with a *work* of about 102 foot-tons, only penetrated to a depth of 2·3 inches in a 3-inch plate, whereas it would have perforated the plate if the *work* had been 114 foot-tons.

The 68-pounder smooth-bore, firing solid steel spherical shot with 16-lb. charges, could perforate a 5-inch plate, but would only penetrate to a depth of about 3 inches in a 5½-inch plate.

The effects of the wall-piece, firing steel flat-headed shot, are very strange. Thus this projectile can penetrate, at 25 yards, all plates up to and including ¾-inch; it fails to penetrate an inch plate, and indents it 0·28 inch, but it indents a 5-inch plate almost as much; and there is no difference whatever between the indent in a 5- and a 4-inch plate. This seems to prove that anything above a 4-inch plate may be regarded as being of infinite thickness, relatively, to a wall-piece projectile.

*Examination of the Results of various Experiments against Targets representing Iron-clad Vessels.*

The experiments before detailed have indicated that the comparative effect produced on iron defences by *steel* shot can be very closely represented by the *vis viva* of the projectile on impact—and that it is of little importance

whether this *vis viva* be the result of a heavy shot and a low velocity, or a light shot and a high velocity. Thus the 10·5-inch gun with a spherical steel shot of 165 lbs., and a charge of 35 lbs., gives a striking-velocity at 200 yards of 1470 feet, and a "work" on impact at 200 yards of 2472 foot-tons*.

If the same gun be fired with an elongated steel shot of 300 lbs. and charge of 35 lbs., the "work" will be practically the same at 200 yards, viz. 2472 foot-tons.

The effect of these two projectiles may therefore be assumed to be equal; that is, either of them would punch the same hole.

This, however, is only true in the case of projectiles *of the same diameter*; it would not hold good if the comparison had been made between a shot of 10·5 inches diameter, and a shot of 9·22 inches diameter. It is also necessary that the shape of the head, or front part of the shot, should be the same in both cases. Thus, when a comparison is made between a spherical and a cylindrical shot, the head of the latter should be hemispherical. If the cylindrical head be pointed or elliptical, it will have a certain advantage over the spherical form. In the experiments with steel projectiles which have taken place in this country up to the present time, the form of the head has been, generally speaking, hemispherical; the effects there are fairly comparable.

It has been said that the diameters of the shot should be the same, in order to ensure a direct comparison. Recent experiments, however, have shown† that with projectiles of different diameters the *vis viva* should vary as the diameter *nearly*. That is to say, the force required to punch a 10·5-inch hole is to the force required to punch a 9·22-inch hole as 10·5 is to 9·22 *nearly*: so that, if it be found that 2472 foot-tons are required to send a 10·5-inch projectile through the side of an iron-clad, the same effect, as regards penetration, will be produced by 2171 foot-tons in the case of a 9·22-inch projectile.

Let us now examine some of the principal experiments which have taken place in this country in relation to iron-clad sea defences‡.

In the remarks on these structures and the effects observed, the following points will be chiefly attended to, viz.:—

1st. Experiments against targets which represent actual sea-going vessels.

2nd. The effects produced by guns of those calibres only which are likely to be carried on board ship.

3rd. In most cases, solid steel shot.

The accompanying brief description of the several targets alluded to in the Tables is inserted here for reference.

*Warrior*.—This target represented a portion amidships of the frigate of that name. It is a specimen of an iron armour-plated ship.

* The *vis viva* of a body in motion is the whole mechanical effect which it will produce in being brought to a state of rest, without regard to the time occupied; and it varies as the weight of the body multiplied by the square of its velocity.

This mechanical effect, or "work" accumulated in the moving body, is represented by the weight which it is capable of raising 1 foot high, and is equal to the weight of the moving body multiplied by the square of its velocity, and divided by twice the force of gravity, or $\frac{Wv^2}{2g}$.

Thus, if a shot of 165 lbs. weight be moving with a velocity of 1470 feet per second, the "work" accumulated in it will be represented by

$$\frac{165 \times 1470 \times 1470}{2 \times 32{\cdot}1908},$$

which is equal to 5538048 lbs., or 2472 tons. That is to say, the force stored up in this shot is capable of lifting a weight of 2472 tons 1 foot high.

† See Table III.

‡ See Tables in Appendix.

The following are the scantlings:—$\frac{5}{8}$-inch iron skin laid on the 18-inch iron ribs of the ship; 18-inch teak backing composed of timbers 9″ × 9″, the inner tier being laid horizontally, the outer tier vertically; 4½-inch iron armour plates. The whole supported by strong diagonal braces.

The iron armour plates were tongued and grooved.

*Minotaur.*—This target consisted of 3 plates, 5·5 inches in thickness.

The backing consisted of 9 inches of teak, and the inner skin similar to 'Warrior.'

Each plate was fastened by three rows of bolts, the upper and lower rows being 1·75 inch diameter, and the centre row 1·5 inch. The majority of the bolts went completely through, having double nuts on the inside; but some of them were screwed into the teak backing, being in fact only large wood screws. Strips of iron, 1·25 inch thick, were placed in rear, at the junction of the plates, the upper strip being 16 inches wide, the lower strip 10 inches wide.

The supports in rear were similar to that of the 'Warrior' target. It appears, therefore, that this target differs from the 'Warrior' by the substitution of 1 inch of armour plate for 9 inches of teak backing.

*Bellerophon.*—Each frame of the target was made of an angle-iron 10″ × 3½″ × ½″, and two angle-irons 3½″ × 3½″ × $\frac{5}{8}$″, rivetted together. To the double angle-irons of this frame, the skin, which was composed of two thicknesses of ¾″ plating, making together 1½″, with a layer of painted canvas between, was rivetted.

On the outside of the skin plating four horizontal angle-iron stringers were attached, two under the upper armour plate, 9½″ × 3½″ × ½″, the broad flange being square to the skin, and not reaching out to the armour by half an inch; the other two were placed behind the lower plate, 10″ × 3½″ × ½″. The breadth of the broader flange being thus equal to the backing, it rests against the armour. The wood backing, 10″ thick, was worked longitudinally on the skin plating, and between the angle-iron stringers, and bolted with nut-and-screw bolts through the skin plating. The armour consisted of two rolled plates, 6″ thick, weighing upwards of 9 tons each. The upper armour plate was bolted with 2½-inch bolts, the lower plate with 2¾″ bolts. The bolts ran through, and were secured by nuts and washers. In erecting the target, care was taken to support it behind with beam ends, &c.; so that the actual condition of the proposed ship's side was approximated to as closely as possible*.

*Lord Warden.*—This target represents the ordinary construction of a wooden ship, armour-plated, with the addition of a thick iron skin worked outside of the frame-timbers of the ship.

The following are the scantlings:—Frame-timbers moulded, 12½″; iron diagonal riders connecting the frame-timbers, 6″ by 1¼″; inner planking 8″ thick; iron skin 1½″ thick; outside planking 10″ thick; rolled armour plates 4·5 inch thick.

Armour-plate bolts 2½″ diameter.

Iron washers were placed under the bolt-heads, and rested on india-rubber washers, the latter being let into the timber.

| | |
|---|---|
| Deck-beams, lower | 15″ by 12″ |
| ,, upper | 16 by 16 |
| Waterway, lower | 15 by 15 |
| ,, upper | 13 by 14 |

* Transactions and Reports of the Special Committee on Iron, page 195, 1863.

| | |
|---|---|
| Deck-planking, lower | 4″ |
| „ upper | 4 |

Iron knees to each beam.

*Small Plate.*—This target represents the ordinary construction of a wooden ship armour-plated, the armour plates being of small area, and secured by large wood screws. The target was faced with four rows of plates of the following dimensions:—

| | |
|---|---|
| Two upper rows | 5′ 9″ × 2′ 7″ × 4·75″ |
| Two lower rows | 5 9 × 2 5 × 5·9 |

The following are the scantlings:—Timber frames 11″; inner planking 6″; outside planking 10″.

The target was furnished with deck-beams, waterway, and deck-planking. Massive wooden knees to each beam.

*The Hercules.*—This was the strongest target ever fired at at Shoebury-ness; indeed, it is probable that a structure of such immense strength has never yet been tried in any other country.

The upper half of the target was faced with a wrought-iron plate 9 inches thick, and the lower half with a similar plate 8 inches thick. Behind both plates was a compact backing consisting of 12-inch timber, laid horizontally, and divided by four horizontal iron plates placed edgewise. This backing rested against a skin of two $\frac{3}{4}$″ plates. The whole was secured to the iron ribs, which were 10 inches deep, with vertical timber worked in between them. Behind the ribs were two linings of horizontal timber 18 inches deep, confined by 7-inch iron ribs inside all, and an inside iron skin. The armour plates were secured by 3-inch bolts.

The total thickness of the target, wood, and iron, exclusive of the 7-inch inside ribs, was:—At top, 51·25 inches; at bottom, 47·25 inches. It may easily be imagined that a structure such as this, 4 feet thick, presented a very serious obstacle to the passage of any nature of projectile.

*Mr. Chalmers's Target.*—This target was composed of 3·75-inch hammered armour plates, with a compound backing 10·75 inches thick, formed of horizontal layers of wood and iron plates. Behind this was a second armour plate $1\frac{1}{4}$ inch thick, with a cushion of timber 3·75 inches thick between it and the $\frac{5}{8}$-inch plate, which formed the skin of the ship.

The iron plates used in the backing were $\frac{5}{8}$-inch in thickness, and 5 inches apart from centre to centre.

The armour plates were secured by through bolts.

*7½-inch Target*—This target consisted of a 7·5-inch rolled armour plate 11′ 9″·25 × 3′ 8″·37 × 7″·5, backed by 7 inches of wood, and secured to the frame of Mr. Samuda's target* (2½ inches thick), the plates being secured by 2½-inch conical-headed bolts with double nuts.

*6½-Inch Target.*—This target consisted of a 6½-inch rolled armour plate, backed by 17 inches of wood, and on 'Warrior' skin and frame†.

*Portsmouth A.*—This target consisted of a rolled armour plate 5·5 inches thick, bolted to the sides of a wooden line-of-battle ship. The backing was therefore about 25 inches of oak.

*Portsmouth B.*—Exactly the same as the above, with the exception of the armour plate, which was 6 inches thick.

*Portsmouth C.*—Exactly the same as the above, with the exception of the armour plate, which was 4·5 inches thick.

* Transactions, p. 102 (1862). † Ibid. p. 173 (1863).

Let us now examine the results of the various experiments given in the Appendix Tables*.

*The Lord Warden.*—It appears from round 813, that this vessel could be completely penetrated by a steel shot of 9·14 inches diameter, striking with a stored-up work of 2642 tons.

The gun in this case used a reduced charge of 30 lbs. We learn from this that, had the full charge, viz. 44 lbs., been used, it would have been equivalent to a removal of the gun to something over 1000 yards from the target.

The 9·22-inch gun of 12 tons, with an elongated steel shot of 221 lbs. and charge of 44 lbs., is therefore capable of completely piercing an iron-clad vessel of the 'Lord Warden' class at 1000 yards.

We have before mentioned that recent experiments have indicated that for complete penetration through iron, the "work" must vary as the diameter of the shot nearly.

If, therefore, we were to use a 10·5-inch gun against the 'Lord Warden,' the force required to obtain the same effect as that accomplished by the 9·22-inch with a striking-"work" of 2642 tons, would be expressed by the following proportions:—

$$9{\cdot}14 : 2642 :: 10{\cdot}43 : x;$$

and we find $x = 3015$.

The 10·5-inch gun would therefore require a force of 3015 tons to completely penetrate the 'Lord Warden.' That this reasoning is nearly correct, we find by observing the effects of round 806, where a steel shot of 10·43 inches diameter, struck with a "work" of 2898 tons, *and failed to get completely through.*

In the same manner we can approximately determine the effect which would be produced by any other steel shot of given diameter and weight.

Let us take, for example, the 15-inch and 11-inch cast-iron smooth-bore guns used in the United States.

The first of these guns would throw, provided they had such projectiles, a spherical steel solid shot of 484 lbs. weight, and 14·85 inches diameter, with a maximum battering charge of, say, 50 lbs.

The second gun would fire a steel solid shot of 189 lbs. with a charge of 20 lbs.

The following Table shows the remaining velocities of these projectiles at various distances, with their corresponding stored up "work:"—

TABLE VIII.—Showing the remaining velocities and "work" of spherical steel solid shot fired from 15-inch and 11-inch guns.

| Gun. | Charge. | Projectile. | | Initial velocity. | At 200 yards. | | At 500 yards. | | At 1000 yards. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Weight. | Diameter. | | Remaining velocity. | Vis viva. | Remaining velocity. | Vis viva. | Remaining velocity. | Vis viva. |
| | lbs. | lbs. | inches. | feet. | feet. | tons. | feet. | tons. | feet. | tons. |
| 15-inch... | 50 | 484 | 14·85 | 1070 | 1028 | 3547 | 969 | 3152 | 880 | 2599 |
| 11-inch... | 20 | 189 | 10·85 | 1080 | 1019 | 1361 | 936 | 1148 | 818 | 877 |

From this Table we can approximately determine the effect of 15-inch and 11-inch steel projectiles. Thus, assuming that the penetration varies in-

* The projectiles are assumed to strike direct.

versely as the diameter, and that it requires 2642 tons of "work" on impact to send a steel shot of 9″·14 through the side of the 'Lord Warden;' the penetration of a steel shot from the 15-inch gun will require a force represented by the following proportion:—

$$9{\cdot}14 : 2642 :: 14{\cdot}85 : x;$$

and $x = 4292$ tons. It would therefore require a force of 4292 tons to send a steel shot of 14·85 inches diameter through the 'Lord Warden.'

A glance at the last Table shows that the 15-inch gun, if fired with a 50-lb. charge, is unable to accomplish this even at a range of 200 yards; and it is further very doubtful whether this gun, fired with 50 lbs. of powder, and a solid steel shot of 484 lbs., would penetrate the side of the iron-clad ship 'Lord Warden,' *even were the muzzle of the gun touching the armour plates of the vessel.*

It is needless to remark that the 11-inch gun would be much less effective.

These conclusions go to prove—

1st. That the 7-inch M L gun of 134 cwt. rifled, fired with a solid elongated steel shot of 100 lbs. and charge of 25 lbs., is not capable of piercing the 'Lord Warden' at any range.

2nd. The same remark applies to the 100-pounder smooth-bore gun with a spherical steel shot of 104 lbs. and 25 lbs. charge.

3rd. The 9·22-inch rifled gun of 12 tons, fired with an elongated steel shot of 221 lbs. and 44 lbs. charge, is capable of piercing the 'Lord Warden' up to a range of about 1000 yards.

4th. That the same remark applies to the 10·5-inch gun of 12 tons, fired with a solid elongated shot of 301 lbs. and charge of 45 lbs.

5th. That the American smooth-bore guns of 15, 13, 11, and 9-inch calibre, fired with solid spherical steel shot and their service charges, are not capable of piercing the 'Lord Warden' at any range whatever.

6th. This vessel could steam past batteries armed with the above smooth-bore guns without suffering except from "racking" effect.

*The Bellerophon.*—The trial of this target was of such an undecided character, and of such a comparatively mild form, that it is difficult to obtain sufficient data upon which to base any comparison between this vessel and other iron-clads. The most severe blow it encountered was from the 10·5-inch rifled gun, with a spherical steel shot of 165 lbs. and charge of 35 lbs., the striking "work" being 2472 tons. This shot failed to penetrate the target; but we have no evidence to prove that the 10·5-inch gun would not have penetrated with a charge of 50 lbs., and striking "work" of 2898 tons. The 'Bellerophon' is undoubtedly of a stronger construction than the 'Warrior' or 'Minotaur' class; but there is no direct evidence to prove that it is as strong or stronger than the 'Lord Warden.'

We have seen that 75·4 foot-tons per inch of shot's circumference has failed to penetrate the 'Bellerophon;' but it appears that this force is quite sufficient to penetrate this target when the plates are 5·5 inches thick instead of 6 inches (rounds 949 to 952). We have no evidence, however, whether 75 foot-tons per inch may not be too much for a 'Bellerophon' with 5·5-inch plates. If we assume that this force is only sufficient for the penetration of 5·5-inch plates on a backing and skin similar to the 'Bellerophon,' the latter with 6-inch plates would require a force of 89·6 foot-tons per inch, which is about what is required by the 'Lord Warden.'

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The fact, however, of the 10·5 inch gun having failed to pierce this target, indicates that the American smooth-bore 15-inch gun fired with solid steel shot and 50 lbs. charge, would not penetrate it at any distance over 100 yards. This vessel, therefore, could pass batteries so armed without suffering, except by "racking."

*The Warrior.*—The only steel shot which have been fired at the 'Warrior' target have been from 100-pounder and 68-pounder smooth-bore guns, and the 7-inch rifled gun, and 6·3 and 5-inch rifled guns. We see from the Table that the 7-inch rifled gun is capable of piercing the side of this vessel with a 100-lb. shot and 20-lb. charge, the striking "work" being 1374 tons (round 1018). The effect of the 100-pounder gun would, therefore, be represented by the proportion

$$6{\cdot}91 : 1374 :: 8{\cdot}87 : x ;$$

and $x = 1764$.

The force, therefore, required to send a steel shot from the 100-pounder gun through the 'Warrior' would be about 1764 tons; and we may assume that any force under this would not produce the required effect.

Thus we find (round 972) that a shot from the 100-pounder struck the 'Warrior' with a force of 1573 tons, but failed to penetrate. In the same manner we can approximate to the force required to send a shot from the 9·22-inch gun through the 'Warrior,'

$$6{\cdot}91 : 1374 :: 9{\cdot}14 : x ;$$

and $x = 1813$ tons.

The 9·22-inch gun could therefore send a steel shot through the 'Warrior,' provided the striking force were 1813 tons.

If the shot, therefore, was 221 lbs. weight, the necessary velocity would be 1087 feet; and if the gun were fired with its full charge of 44 lbs., it would send an elongated steel shot of 221 lbs. through the 'Warrior' at 2500 yards range.

In the same manner, in the case of the 10·5-inch gun, we have the proportion

$$6{\cdot}91 : 1374 :: 10{\cdot}43 : x ;$$

and $x = 2074$.

The 10·5-inch gun would therefore send its shot through the 'Warrior,' provided the striking-force were 2074 tons.

From this it appears that the 'Warrior' is of weaker construction than the 'Lord Warden,' as the 10·5-inch gun failed to penetrate the latter with a striking-force of 2898 tons.

In the case of the 15-inch American gun, we have the proportion

$$6{\cdot}91 : 1374 :: 14{\cdot}85 : x ;$$

and $x = 2953$ tons.

From Table VIII. it appears that the 15-inch gun, fired with a spherical steel shot of 484 lbs. and a charge of 50 lbs., would penetrate the 'Warrior' at any distance up to 500 yards, but would not do so at 1000 yards.

In the case of the 11-inch gun, we have

$$6{\cdot}91 : 1374 :: 10{\cdot}85 : x ;$$

and $x = 2157$.

And from Table VIII. we find that the 11-inch gun, fired with a solid steel shot of 189 lbs. and charge of 20 lbs., would not penetrate the 'Warrior' at any range, not even if the muzzle of the gun were touching the armour plates.

From these considerations the following effects are probable:—

1st. The 7-inch muzzle-loading rifle-gun of 130 cwt., with a solid steel shot of 100 lbs. and charge of 25 lbs., is capable of piercing the side of the 'Warrior' up to a range of 600 yards *.

2nd. The 100-pounder smooth-bore gun (9-inch) of 125 cwt. with a solid spherical steel shot of 104 lbs. weight and 25 lbs. charge, is not capable of piercing the 'Warrior' at any distance over 100 yards.

3rd. The 9·22-inch rifled gun of 12 tons, with a solid elongated steel shot of 221 lbs. and charge of 44 lbs., is capable of piercing the 'Warrior' up to a range of 2500 yards †.

4th. The 10·5-inch rifled gun of 12 tons, with a solid elongated steel shot of 301 lbs. and charge of 45 lbs., is capable of piercing the 'Warrior' up to a range of 2500 yards.

5th. The American 15-inch gun of 22 tons, with a spherical steel shot of 484 lbs. and charge of 50 lbs., is capable of piercing the 'Warrior' up to a range of 500 yards.

6th. The American smooth-bore 11-inch and 9-inch guns, fired with solid spherical steel shot and their maximum charges, are not capable of piercing the 'Warrior' at any range.

7th. This vessel could pass batteries armed with 15-inch guns, as above, at a distance of 800 yards without suffering, except by "racking."

*The Minotaur.*—This class differs from the 'Warrior' in having 1 inch of iron armour plating substituted for 9 inches of wood backing.

In the trial of this target, an experimental powder named $2A_4$ was made use of; and this accounts for the effects observed with the 10·5-inch gun.

It appears that, when the ordinary service, powder was used, the result was something the same as in the case of the 'Warrior.'

The actual strength of these ships may therefore, in absence of direct evidence to the contrary, be assumed to be equal; but whether the wood and iron, which combined form the mass of resistance, have been more advantageously distributed in the construction of the 'Warrior' than in that of the 'Minotaur,' is a separate question.

On the whole, it may be assumed that the remarks which apply to the 'Warrior' are equally applicable to the 'Minotaur' and ships of her class.

*The Hercules.*—This target was by far the strongest ever tried at Shoeburyness, and accordingly it received the most severe treatment. The preliminary experiments were made with the 9″·22, 10″·5, and 10″ rifled guns of 12 tons, firing solid steel shot with very high charges.

It appears that rounds 1041, 1045 broke the 8-inch plate and forced the pieces into the 12-inch wood backing. Both these rounds struck between two ribs; 1045, however, met with more resistance than 1041, as it struck just over one of the horizontal plates; the armour plate was thus supported in rear of the point struck by a rigid backing.

An 8-inch plate unbacked requires 88·6 foot-tons per inch of shot's circumference to just penetrate it; it was to be expected, therefore, that the above rounds should do so.

* The same result would probably occur with the present service charge for this gun, viz. 22 lbs. and shot of 115 lbs.

† The same result would occur with the service 9-inch gun of 12 tons.

Rounds 1043, 1044, 1040, 1042 struck the 9-inch plate, which, if unbacked, would require a force of 112·1 foot-tons per inch of shot's circumference to penetrate it. Round 1044 was therefore the only shot which had sufficient force to penetrate the plate; and this round struck both on a rib and full on one of the rigid backings; 1040 almost penetrated the plate, as, although the absolute indent was only 4·5 inches, the piece of plate struck was almost dislodged; 1042 ought to have done more damage than it did; probably the steel was not of the best quality.

The target was subsequently tested by firing at it with the 13-inch wrought-iron gun of 22 tons, using solid steel and chilled iron shot of 570 lbs., with 100 lbs. of powder.

The gun was at 700 yards from the target.

The results proved that the target was impenetrable when struck fair, although it was penetrated by a chilled shot which struck just above a previous round.

When it is considered that this target was only 18·2 feet × 8 feet × 4 feet, and that it received blows amounting in all to over seventy thousand foot-tons, it must be confessed it did its duty.

*The Small Plate.*—This target represented a wooden ship armour-plated, such as the French 'Flandre' &c.

It appears that this class of iron-clad is not quite as strong as that represented by the 'Warrior' or 'Minotaur' (which are iron vessels armour-plated), and of course not nearly so strong as the 'Lord Warden' or 'Bellerophon.'

Thus the 10·5-inch gun with a striking-"work" of 1657 tons penetrated the "small plate" target; and we have seen that this gun would require a striking-force of 2047 tons to send the same shot through the 'Warrior.'

It is hardly fair, however, to take this round (850) for the basis of a comparison with other guns, as it appears that the target had been previously considerably shaken.

On the whole, it may be assumed that vessels of the class represented by the "small plate" target are something weaker than those represented by the 'Warrior,' and that the remarks which apply to the latter are applicable to the former in a greater degree*.

The following Table shows the probable distance at which various guns, firing solid steel shot, with full service charges, would penetrate iron-clad ships at present (1866) in the service:—

* This target is of equal, if not superior strength to the 'Warrior,' if struck on the 5·9-inch plates.

TABLE IX.—Showing the probable distance at which various guns would penetrate existing iron-clad vessels, provided they were fired with full service-charges and solid steel shot.

| Gun. | Supposed charge. | Supposed shot. | Vessel represented by. | Distance at which full charge will penetrate. | Remarks. |
|---|---|---|---|---|---|
| | lbs. | lbs. | | yards. | |
| 13″·3 M L rifled of 22 tons... | 70 | 600 | Omnes* ..... | 2000 | to 4000 yards. |
| 9″ M L rifled of 12 tons ... | 45 | 300 | Lord Warden | 1000 | |
| ,, ,, | 45 | 300 | Bellerophon | 1000 | |
| ,, ,, | 45 | 300 | Warrior..... | 2000 | |
| ,, ,, | 45 | 300 | Minotaur .... | 2000 | |
| ,, ,, | 45 | 300 | Gloire..... | 2200 | |
| 10″·5 M L rifled of 12 tons... | 43 | 250 | Same as 9-in. | | |
| 7-inch M L rifled of 130 cwt. | 22 | 115 | Warrior ..... | 500 | |
| ,, ,, | 22 | 115 | Minotaur .... | 500 | |
| ,, ,, | 22 | 115 | Gloire..... | 600 | to 700 yards. |
| 100-pounder smooth-bore ... | 25 | 104 | Warrior.. ... | 100 | |
| ,, ,, | 25 | 104 | Minotaur ... | 100 | |
| ,, ,, | 25 | 104 | Gloire..... | 200 | |
| 15″ smooth-bore (American) | 50 | 484 | Warrior..... | 500 | |
| ,, ,, | 50 | 484 | Minotaur ... | 500 | |
| ,, ,, | 50 | 484 | Gloire..... | 700 | |

*Résumé of Experimental Results against Backed Plates.*

The experiments which have hitherto been made in this country in connexion with targets representing iron-clad vessels, have been of such a decidedly practical nature that it is difficult to make any theoretical deductions from the results.

The trials have been chiefly for the purpose of testing various specimens of armour-plated vessels; and the guns employed have been of a very varied nature, mostly experimental. The results of such experiments have furnished much valuable practical information; but as they were conducted under such varying circumstances, it is difficult to base any theoretical conclusion on the facts established. We can, however, make several deductions which, if not absolutely, will be relatively true, and will give us some approximation of what is required.

Thus, if we examine the experiments which from time to time have been carried out against targets representing the 'Warrior'†, we find that the target was completely penetrated by a steel shot which struck with a "work" represented by about 63 foot-tons per inch of shot's circumference (round 1018), and that 59 tons failed to penetrate, although it cracked the inner skin (round not numbered).

We may therefore assume that a force of about 60 or 61 foot-tons would be the minimum to ensure the absolute penetration of the 'Warrior' with a steel shot of good quality, striking direct‡.

The round quoted above (1018) consisted of a hemispherical-headed steel shot of 99·56 lbs. and 6·91 inches diameter, moving with a velocity of 1411

* At present afloat (August 1866). † See Table XIII. (in the Appendix).
‡ This applies only to hemispherical-headed shot.

feet; we can therefore find what thickness of unbacked plate it would have penetrated.

From equation (2),

$$b = v\sqrt{\frac{W}{4\pi R g k}},$$

$$b = 6{\cdot}76 \text{ inches.}$$

And as the armour plating of the target was 4·5 inches, the backing, including the inner skin, was equivalent to an extra 2·26 inches of plating. We can also determine the "work" necessary to penetrate the 4·5-inch plate (unbacked) by the above shot. From equation (1),

$$\frac{Wv^2}{2g} = 2\pi R k b^2 = 608{\cdot}4 \text{ foot-tons,}$$

or 28 foot-tons per inch of shot's circumference.

As the total force required to penetrate the target would be 61 foot-tons per inch, we see that this may be divided into twenty-eight for the armour plate, and thirty-three for the backing.

It is, however, possible that this backing might be penetrated with greater ease if it depended on itself alone; and possibly it is only when combined with the armour plate that its resistance is so great*.

That this reasoning is approximately correct, we find by examining the results of round 979.

Here the striking-"work" was 22 foot-tons per inch, and, as might be expected, the plate was not penetrated; again, round 736 struck with 39 tons per inch, and penetrated the plate, driving the pieces into the backing.

We learn from the foregoing results that any good hemispherical-headed steel shot will penetrate a structure like the 'Warrior,' provided the striking-"work" be not less than about 61 foot-tons per inch of shot's circumference, and that the shot hits direct †.

In the absence of direct proof to the contrary, we may assume that the same results would take place in the case of the 'Minotaur' and ships of her class.

If we examine the results of round 1 in the Portsmouth experiments, it appears that a spherical steel shot of 113·81 lbs. weight and 9·15 inches diameter, moving with a velocity of 1450 feet, and consequent "work" of 57·7 foot-tons per inch, penetrated a 5·5-inch plate and the side of a wooden frigate, viz. 25 inches of wood.

The amount of "work" due to the plate was here 41·4 foot-tons per inch, which leaves 16·3 tons for the backing.

It will be seen from this that the backing and inner skin of an iron-built ship like the 'Warrior' is capable of much greater resistance than the side of an ordinary frigate.

If we suppose the ship to have been protected with the 4·5-inch armour plates, as in the case of "Portsmouth C" target, the resistance will be approximately proportioned to the squares of the thicknesses of the plates, the backing being the same in both cases.

We might therefore expect that a "work" of about 44 tons per inch would penetrate "Portsmouth C." It appears from round 4 that 38·7 foot-tons per inch failed to penetrate this target.

* We have no experimental data to determine this point.

† The above only applies to hemispherical-headed shot; if the projectile be ogival-headed the "work" required will be less.

As before stated, it is proved that a "work" of about 58 foot-tons per inch of shot's circumference will just penetrate a 5·5-inch plate and 25 inches of wood; and we may assume that it will require a force of 44 foot-tons per inch to penetrate the same ship if the plates be 4·5 inches.

In order to demonstrate how this knowledge may prove of advantage, let us suppose the following case.

H.M.S. 'Favourite' is a wooden ship of about 22 inches thickness, protected by 4·5-inch plates, and armed with 7-inch M L rifled guns throwing solid elongated steel shot of 115 lbs. weight and 6·92 inches diameter, with a charge of 22 lbs.

Suppose this ship meets an enemy's vessel of the same thickness, but protected by 5·5-inch plates, and armed with 11-inch smooth-bore guns throwing solid spherical steel shot of 189 lbs. weight and 10·85 inches diameter, with a charge of 20 lbs.

To all appearance the enemy's vessel is much the stronger of the two. We find, however, that at 500 yards the 11-inch projectiles would strike with a "work" of only 34 foot-tons per inch of shot's circumference, and consequently would fail to penetrate the 'Favourite,' which requires a force of about 44 foot-tons; while, on the other hand, the projectiles from the rifled guns of the latter ship would at 500 yards strike with a "work" of about 65 foot-tons per inch of shot's circumference, which would be amply sufficient to penetrate, even with steel or chilled *shells*, the side of a ship of 22 inches thickness, protected by 5·5-inch plates.

It may, however, be urged that, although the 11-inch shot could not penetrate, they would have great battering effect. But it is submitted that the projectile which can perforate the side of an enemy's ship and disable her crew, machinery, or magazine, is decidedly to be preferred. Battering is all very well in theory, but we know what a battering the 'Tennessee' stood without being much injured; and if the 'Favourite' should ever happen to fall in with an enemy's wooden frigate protected by 5·5-inch plates and armed with big smooth-bore guns, she will most likely be able to dispose of her in a satisfactory manner.

If we examine the experiments carried out against the 'Lord Warden' target, it appears that the target was completely penetrated by a force represented by 92 foot-tons per inch of shot's circumference, while 88 tons per inch failed to penetrate, although it evidently very nearly did so. We may assume from this that a force of about 90 tons per inch is just capable of piercing the 'Lord Warden.'

Now this ship consists of—

1st. A 4·5-inch armour plate.
2nd. 8½ inches of wood backing.
3rd. A 1·5-inch iron plate.
4th. 20½ inches of wood.

And if we assume the force required to penetrate the iron part of it to vary as the squares of the thicknesses of the plates, we shall have 28 tons for the 4·5-inch plate, and 3·1 tons per inch for the 1·5-inch plate, thus leaving 58 tons for the backing and wood. This seems a large amount, but we must remember that the target is very thick. We have, unfortunately, no data upon which we can depend relative to the penetration of backing and the effect of dividing it by vertical iron plates of less thickness than the principal armour plate. It is probable, however, that the strength of the 'Lord Warden' would have been increased had the 1½-inch inner plate been differently dis-

posed. It would have been interesting to find the effect of adding one inch to the armour plate and supplying a ½-inch iron skin.

*On the effect of Backing to Iron Plates.*

It might appear at first sight that wood backing would have the effect of strengthening an iron plate; the results, however, of a very large number of cases go to prove the opposite—namely, that the backing affords little, if any, support to the plate, unless it be of the rigid form, such as the 'Hercules' and 'Bellerophon.' In other words, if a shot is capable of perforating an unbacked 4½-inch plate, it will perforate it or break it away equally if it be backed by wood alone.

We have many instances of this. Thus we find that a steel shot fired from the 68-pounder perforated 4½-inch plates on the 'Warrior,' 4¾-inch plates on the Small Plate, a 5-inch plate (round 960), and penetrated to the same depth in 5½-inch unbacked and backed plates.

We have evidence, however, that a rigid backing is a great advantage; this was particularly apparent in the case of the 'Hercules,' where the plates were not perforated by some shot which struck with sufficient "work" to penetrate them completely if unbacked.

We have also evidence of the great superiority of packed backing of teak, such as in the 'Warrior,' 'Minotaur,' &c., over the ordinary side of a line-of-battle ship, and of the great support which an inner skin affords.

Thus it required 33 foot-tons per inch of shot's circumference to penetrate the backing and skin of the 'Warrior,' viz. 18 inches of compact teak and a ½-inch iron plate, strengthened and supported by iron ribs; and we see that 16 foot-tons per inch were sufficient to penetrate the side of an ordinary line-of-battle ship, viz. 25 inches of oak.

We also find that the backing of the 'Lord Warden' required 58 tons per inch, and of the Small Plate target about 16 tons per inch. This shows the vast superiority of compact backing supported by internal iron plates.

*Résumé of the Conclusions which may be drawn from the experiments against iron.*

1. When it is required to perforate the plate, the projectile should be of a hard material, such as steel or chilled iron.

2. The form of head best suited for the perforation of iron plates, whether direct or oblique, is the pointed ogival.

3. The best form of steel shell is that in which the powder can act in a forward direction, and which is furnished with a solid steel head in the form of a pointed ogival.

4. When chilled iron can be made of the best quality, it is almost, if not quite, as effective as steel for solid shot. And where the projectile can perforate with ease, the chilled shot is more formidable than steel, as it enters the ship broken up, and would act as grape *.

5. To attack well-built iron-clads effectively, the guns should be, if possible, not under 12 tons weight and 9 inches calibre, firing an elongated projectile of 250 lbs. with about 40 lbs. of powder.

6. When the projectiles are of a hard material, such as steel, the perforation † is directly proportional to the "work" in the shot, and inversely proportional to the diameter of the projectile; and it is immaterial whether this

* The introduction of chilled iron is due to Major Palliser, who has devoted much time and attention to the subject.

† Or power of complete penetration.

"work" be made up of velocity or weight, within the usual limits which occur in practice.

7. The resistance of wrought-iron plates to perforation by hemispherical-headed steel projectiles varies as the square of their thickness.

8. Hitting a plate at an angle diminishes the effect as regards power of perforation in the proportion of the sine of the angle of incidence to unity.

9. The resistance of wrought-iron plates to perforation by steel shot is not much (if at all) increased by backing simply of wood; it is, however, much increased by a rigid backing, either of iron combined with wood, or of granite, iron, brick, &c.*

10. Iron-built ships, in which the backing is composed of compact oak or teak, offer much more resistance than similarly clad wooden ships.

11. The best form of backing seems to be that in which wood is combined with horizontal plates of iron, as in the Chalmers, 'Bellerophon,' and 'Hercules' targets.

12. An inner iron skin is of the greatest possible advantage; it not only has the effect of rendering the backing more compact, but it prevents the passage of many splinters which would otherwise find their way into the ship.

No iron-clad, whether iron-built or wooden converted, should be without an inner iron skin.

13. The bolts known as "Palliser's bolts," are the best for securing armour plates.

In these bolts the diameter of the shank is reduced, so that it is less than the diameter at the screwed end.

In the foregoing pages great stress has been laid on *penetration*.

There are two methods by which an iron-clad vessel can be destroyed by the fire of artillery.

1. *Racking* †, or the impact of heavy shot of large size moving at low velocities, and intended to shatter the vessel's armour, and by repeated shakes ultimately to knock the whole structure to pieces.

2. *Punching* ‡, or the penetration of the vessel's side either by elongated shot or shell, intended to kill the crew, damage the machinery, and sink the vessel by holes made through her, at or near the water-line.

Both these systems have their advocates, and there is undoubtedly a great deal to be said on both sides.

All warlike operations tend to the crippling of your enemy; and that system is evidently the best which will cripple him in the shortest time, in the easiest manner, and at the least possible expense.

Now *time* is an element which will largely enter into consideration in future actions with iron-clad vessels.

Suppose two opposing iron-clads to meet, one armed with guns on the "racking" system, the other with guns on the "punching system;" it is probable that the vessel which could send her shot clean through the sides of her adversary would have the greatest *chance* of reaching a vital part *in a given time*. Besides which, a "punching" shot is usually an elongated rifle projectile, animated by a moderately high velocity, and has consequently a *flatter trajectory* than the "racking" shot, which travels at a low velocity; and as accuracy and a flat trajectory are closely allied, the "punching"

* That is to say, a shot which is capable of breaking a hole through a 4·5-inch plate unbacked, will be also capable of doing so if the plate be only backed by wood, to the extent that, were the plate taken off the backing, the piece of iron where the shot had struck would fall out.

† American system. ‡ English system.

system would gain another chance, viz. that of making the greatest number of hits for a given number of shots.

Suppose an iron-clad is desirous of running past a fort which defends an important harbour or roadstead, she would, if possible, probably pass at a rate of over 10 miles an hour. The fort in this case would only have time to fire a few rounds at her; and if the effect of those rounds was merely an external racking, the vessel might receive no real injury at all—nothing, at least, which would in all likelihood stop her. On the contrary, a happily directed punching shot would have the chance of destroying the machinery, blowing up the magazine, or establishing a leak at the water-line.

In attacking an iron-clad by the racking system, the whole effect is directed against the casing or armour plating of the vessel, which, for all offensive purposes, is harmless; the enemy which we want to cripple are the men and guns behind the armour.

It appears from these considerations that an attack on the "punching" system will probably be attended with gain in time, as the vital parts of the vessel cannot be reached so quickly by an attack on the "racking" system; and even were an enemy's ship ultimately shattered, and her offensive power destroyed by the effect of heavy blows, *this result might not be effected before she accomplished her object, partly, if not altogether.*

The attack on the "punching" system is carried on in an easier manner than that on the "racking" system. The former employs light rifle guns, from 6 to 12 tons, the latter unwieldy heavy ordnance of from 12 to 50 tons. The "racking" projectiles are heavy cast-iron shot fired with relatively small charges; and the loading and working of such projectiles and guns cannot be carried out as easily or expeditiously as in the case of a system which uses a lighter shot and relatively larger charge.

The question of expense is one which, although it should come last in an inquiry of this nature, is too often made the most important consideration. If, however, we compare the cost of the 9-inch 12-ton gun, as fairly representing the "punching" system, and the American 15-inch smooth-bore gun as representing the "racking" system, we shall find that the total cost of gun, carriage, and 100 rounds of ammunition is very much the same for each gun.

On the one hand, the money will have procured a gun which *can* send a shot, and possibly may send a shell, through the strongest iron-clad yet afloat at 1000 yards range. On the other hand, a gun will be obtained which, if fired with service charges, cannot pierce the above ship at any distance whatever—whose shot at 1000 yards would, if cast iron, merely indent the armour and fall back broke into the water, and if steel, would merely lodge in the ship's side, and whose shell would be absolutely worthless against an iron-clad, and even against wooden ships or earthworks, inferior to the 9-inch rifle shell both in accuracy and bursting-power.

# APPENDIX.

TABLE IX. (A).—Showing the results of practice with steel projectiles fired at 4·5-inch unbacked plates, placed at an angle.

| No. of round. | Target. | Gun. | Charge. | | Projectile. | | | Striking-velocity. | $\frac{Wv^2}{2g}$ in foot-tons on impact. | Foot-tons per inch of shot's circumference. | Observed effects. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Weight. | Br nd of Powder. | Nature and Length. | Weight. | Diam. | | | | |
| | | | lbs. | | | lbs. | ins. | feet. | | | |
| 1. | 4·5-inch unbacked plate at an angle of 38°. | 70-pounder M L Armstrong competitive gun. | 14·0 | Rifle L G | Cy'indrical steel shot. | 70·0 | 6·34 | 1470·0 | 1049 | 52·7 | Struck centre of plate, made an indent of 15 inches long and 7 inches broad, and a hole about 2 inches square through the plate. Two large pieces were torn off the back of the plate and driven to the rear. Shot broke up. |
| 2. | " | " | 14·0 | " | " | 70·0 | 6·34 | 1470·0 | 1049 | 52·7 | Made an indent 14 inches long, 4½ inches deep, and 6½ in. broad. Plate cracked through and opened out at back, from which a large piece was torn. Shot broke up. |
| 3. | | " | 14·0 | " | " | 70·0 | 6·34 | 1470·0 | 1049 | 52·7 | Made an indent 14 inches long, 7 inches broad, and 5½ inches deep. Back bulged and cracked through; a large piece of the back torn off. Shot broke up. |

TABLE IX. (B).—Showing the results of practice with a wall-piece at ¾-inch unbacked plates, placed at different angles.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2. | Unbacked ¾-inch plate placed at angles of 60° | Wall-piece ..... | 10 | Rifle F G | Cylindrical steel shot with flat head. | 0·344 | 0·87 | 1141 | 3·1054 | 1·136 | Indent 0·53 inch, plate bulged behind. |
| 2. | Ditto at 45° | " | 10 | " | " | 0·344 | 0·87 | 1141 | 3·1054 | 1·136 | Indent 0·68 inch, plate bulged behind. |
| 2. | Ditto at 30° | " | 10 | " | " | 0·344 | 0·87 | 1141 | 3·1054 | 1·136 | Indent 0·50 inch, plate slight bulge behind. |
| 2. | Ditto at 20° | " | 10 | " | " | 0·344 | 0·87 | 1141 | 3·1054 | 1·136 | Indent 0·54 inch, plate no bulge behind. |
| 2. | Ditto at 10° | " | 10 | " | " | 0·344 | 0·87 | 1141 | 3·1054 | 1·136 | Small piece of plate scooped out. No bulge behind. |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 630. | 2·5-inch plate unbacked (upright) | 12-pounder B L Whitworth gun. | 1·75 | Rifle L G | Flat-headed steel shot. | 12·1 | 2·97<br>2·71 | 1264 | 134·05 | 14·64 | Through plate and into earth-butt behind. |
| | Ditto at 45° ..... | „ | 1·75 | „ | „ | 12·1 | 2·97<br>2·71 | 1264 | 134·05 | 14·64 | Clean hole through, but not sufficient to admit shot, which rebounded. |
| | Ditto at 45° ..... | „ | 1·75 | „ | „ | 12·1 | 2·97<br>2·71 | 1264 | 134·05 | 14·64 | Struck near above round. Clean hole through; shot fell inside at foot of plate. Not fair hit. (Transactions, p. 88, 1862.) |
| | Ditto (upright) ... | 12-pounder M L Whitworth gun. | 1·50 | „ | „ | 12·1 | 2·97<br>2·71 | 1120 | 105·25 | 11·49 | Penetrated plate. |

TABLE X.—Showing the absolute thickness of unbacked plate which can be penetrated by cast-iron shot.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Unbacked plate 1·286 | 6-pounder B L rifled gun. | 0·75 | Rifle L G | Elongated cast-iron shot. | 6·25 | 2·50 | 1010 | 44·21 | 5·63 | Just penetrated through the plate. |
| | 1·803 | 12-pounder B L rifled gun. | 1·50 | „ | „ | 11·56 | 3·00 | 1140 | 104·1 | 11·05 | Just penetrated through the plate. |
| | 2·350 | 20-pounder „ | 3·13 | „ | „ | 24·81 | 3·75 | 1120 | 215·8 | 18·32 | Just penetrated through the plate. |
| | 2·820 | 40-pounder „ | 5·00 | „ | „ | 41·20 | 4·75 | 1150 | 377·8 | 25·32 | Just penetrated through the plate. |
| | 3·850 | 68-pounder smooth-bore. | 1·6 | „ | Spherical cast-iron shot. | 66·50 | 7·91 | 1380 | 878·0 | 35·30 | Just penetrated through the plate. |

TABLE XI.—Showing the results of practice with steel and chilled shot at box target.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1186. | Box target 6-inch plate on 18 ins. of teak and a skin of two ½-inch plates, ribs, &c. | 7-inch M L rifled gun of 130 cwt. | 22 | Rifle L G | Chilled shot E. 13·62 | 117·0 | 6·9 | 1328·5 | 1432 | 66·06 | Struck fair between two ribs, penetrated armour plate, and stuck in backing. Shot broke up and remained in the hole; indent 15 inches. |
| 1190. | „ | „ | 22 | „ | „ | 116·5 | „ | 1331·4 | 1432 | 66·06 | Struck near 1186, between two ribs; shot penetrated to inner skin, which it bulged slightly. Shot remained broken up in the hole. |

TABLE XI. (*continued*).

| No. of round. | Target. | Gun. | Charge. | | Projectile. | | | Striking-velocity. | $\frac{Wv^2}{2g}$ in foot-tons on impact. | Foot-tons per inch of shot's circumference. | Observed effects. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Weight. | Brand of Powder. | Nature and Length. | Weight. | Diam. | | | | |
| | | | lbs. | | | lbs. | inches. | feet. | | | |
| 1191. | Box target, 6-inch plate on 18 ins. of teak and a skin of two ½-inch plates, ribs, &c. | 7-inch M L rifled gun of 130 cwt. | 22 | Rifle L G | Chilled shot B.* 14·79 | 116·5 | 6·9 | 1331·4 | 1432 | 66·06 | Struck fair between two ribs, penetrated the target completely. Shot broke to pieces. Skin of target was here only ½ inch. |
| 1192. | ,, | ,, | 22 | ,, | Chilled shot O. 13·86 | 115·0 | 6·9 | 1340 | 1432 | 66·06 | Struck partly on a rib and armour-plate bolt, penetrated the target completely. Shot broke to pieces. |
| 1196. | ,, | ,, | 22 | ,, | ,, | 116·25 | 6·9 | 1332·8 | 1432 | 66·06 | Struck fair between two ribs, penetrated the target completely. Shot broke to pieces. |
| 1189. | ,, | ,, | 22 | ,, | Steel O. 13·25 | 115·5 | 6·92 | 1360 | 1481·4 | 68·14 | Struck fair between two ribs, penetrated the target completely. Shot picked up inside whole, having rebounded off armour plate at rear of box. |
| 1198. | ,, | ,, | 22 | ,, | Hemispherical-headed steel shot. | 115·0 | 6·92 | 1380 | 1518·6 | 69·85 | Struck on rib. Shot penetrated plate and lodged in the backing. Total indent about 18 inches. Rib at back cracked and forced back slightly. |
| 1201. | ,, | ,, | 22 | ,, | ,, | 115·0 | 6·92 | 1371 | 1498·9 | 68·95 | Struck fair between two ribs. Shot penetrated the plate and lodged in the backing. Total indent about 14·5 inches. |
| 1175. | 4·5-inch unbacked plate inclined at an angle of 38° with the ground. | ,, | 22 | ,, | Chilled B. 14·79 | 115·0 | 6·9 | 1339 | 1432·0 | 66·06 | Struck fair, made a jagged hole 1 foot long, and a small hole through the plate. Shot broke into pieces. |
| 1176. | ,, | ,, | 22 | ,, | Chilled O. 13·86 | 115·0 | 6·9 | 1339 | 1432·0 | 66·06 | Struck fair, penetrated the plate. Shot broke to pieces. |
| 1178. | ,, | ,, | 22 | ,, | ,, | 113·0 | 6·9 | 1372 | 1475·0 | 68·04 | Struck fair, penetrated the plate. Shot broke into pieces. |
| 1180. | ,, | ,, | 16 | ,, | ,, | 113·5 | 6·9 | 1253 | 1235·6 | 57·00 | Struck top of plate, scooping out a hole 4½ inches deep. Shot broke to pieces. |

* B. Blunt head. O. Original head.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1183. | 4·5-inch unbacked plate at inclined an angle of 38° with the ground. | 7-inch M L rifled gun of 130 cwt. | 16 | Rifle L G | Steel O. 13·25 | 114·0 | 6·92 | 1240 | 1215·4 | 55·91 | Struck on edge of former hit, scooped out a piece of plate and glanced off. Shot broke. |
| 1184. | ,, | ,, | 16 | ,, | Chilled O. 13·86 | 114·0 | 6·9 | 1277 | 1289·0 | 59·47 | Struck fair, scooped a hole 11 × 6½ inches and about 2 inches deep. Shot broke to pieces. |

TABLE XII.—Table giving the results of various experiments with steel and other projectiles against unbacked wrought-iron armour plates.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 836. | 5·5-inch unbacked plate. | 7-inch BL gun of 81 cwt. | 12 | Rifle LG | Cylindrical steel shot. | 110·00 | 6·88 | 1090 | 906·2 | 41·93 | Shot clean through. |
| 746. | ,, | ,, | 12 | ,, | ,, | 110·75 | 6·88 | 1086 | 906·2 | 41·93 | Clean hole through. Shot stuck in plate. |
| 765. | ,, | ,, | 12 | ,, | ,, | 110·06 | 6·88 | 1090 | 906·2 | 41·93 | Shot just penetrated. |
| 756. | ,, | ,, | 12 | ,, | ,, | 110·87 | 6·88 | 1085 | 906·2 | 41·93 | Shot clean through and into earthwork. |
| 754. | ,, | ,, | 12 | ,, | ,, | 111·00 | 6·88 | 1085 | 906·2 | 41·93 | Clean hole through. Shot stuck in the plate. |
| 1037. | ,, | ,, | 14 | ,, | ,, | 75·62 | 6·88 | 1310 | 899·8 | 41·63 | Clean hole through. Shot remained sticking in the plate. |
| 766. | ,, | ,, | 10 | ,, | ,, | 110·37 | 6·88 | 950 | 690·7 | 31·95 | Indent 2 inches, plate driven back and cracked in rear. |
| 767. | ,, | ,, | 10 | ,, | ,, | 110·62 | 6·88 | 949 | 690·7 | 31·95 | Indent 2·7 inches. Shot broke up. Plate cracked in rear. |
| 772. | ,, | ,, | 8 | ,, | ,, | 110·00 | 6·88 | 850 | 551·1 | 25·50 | Indent 1·8 inch. Shot rebounded. Plate bulged behind and cracked slightly. |
| 774. | ,, | ,, | 6 | ,, | ,, | 110·31 | 6·88 | 710 | 385·6 | 17·84 | Indent 1·8 inch. Shot rebounded. Plate slightly bulged and cracked behind. |
| 1168. | ,, | ,, | 12 | ,, | Chilled shot 12·2 in. | 111·0 | 6·896 | 1002 | 772·8 | 35·7 | Struck fair. Head of shot stuck in plate; base broke up. Indent 3·4 inches; plate cracked and bulged behind. |
| 1169. | ,, | ,, | 12 | ,, | ,, | 112·0 | 6·896 | 997·5 | 772·8 | 35·7 | ,, ,, |
| 1170. | ,, | ,, | 12 | ,, | ,, | 111·0 | 6·896 | 1002 | 772·8 | 35·7 | ,, ,, |
| 894. | ,, | 100-pounder per S B of 6½ tons. | 25 | L G | Spherical steel. | 104·37 | 8·88 | 1477 | 1580 | 56·6 | Through plate and into earth-butt behind. |
| 895. | ,, | ,, | 25 | ,, | ,, | 104·00 | 8·88 | 1480 | 1580 | 56·6 | ,, ,, |

TABLE XII. (*continued*).

| No. of round. | Target. | Gun. | Charge. | | Projectile. | | | Striking-velocity. | $\frac{Ws^2}{2g}$ in foot-tons in impact. | Foot-tons per inch of shot's circumference. | Observed effects. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Weight. | Brand of Powder. | Nature and Length. | Weight. | Diam. | | | | |
| | | | lbs. | | | lbs. | inches. | feet. | | | |
| 898. | 5·5-inch plate unbacked. | 100-pounder S B of 6¼ tons. | 25 | L G | Spherical steel. | 104·37 | 8·88 | 1477 | 1580 | 56·6 | Through plate and into earth-butt behind. |
| 910. | ,, | ,, | 25 | ,, | ,, | 102·62 | 8·86 | 1486 | 1571 | 56·4 | ,, ,, |
| 911. | ,, | ,, | 25 | ,, | ,, | 103·0 | 8·86 | 1484 | 1571 | 56·4 | ,, ,, |
| 887. | ,, | 68-pounder S B of 95 cwt. | 16 | ,, | ,, | 73·5 | 7·91 | 1351 | 930 | 37·4 | Indent 2·9 inches. Lamina off plate in rear. Shot slightly cracked. |
| 888. | ,, | ,, | 16 | ,, | ,, | 72·62 | 7·91 | 1359 | 930 | 37·4 | Indent 2·9 inches. Plate cracked behind. Shot slightly cracked. |
| 885. | ,, | ,, | 16 | ,, | ,, | 73·5 | 7·93 | 1358 | 940 | 37·7 | Indent 3·15 inches. Shot stuck in the plate, slightly cracked; lamina off plate in rear. |
| 906. | ,, | ,, | 16 | ,, | ,, | 76·0 | 7·92 | 1332 | 935 | 37·6 | Indent 2·6 inches. Shot stuck in the plate, slightly cracked. |
| 907. | ,, | ,, | 16 | ,, | ,, | 73·5 | 7·91 | 1351 | 930 | 37·4 | Indent 3·12 inches. Shot stuck in the plate, slightly cracked; a lamina of plate nearly off in rear. |
| 542. | ,, | ,, | 16 | ,, | Spherical cast-iron. | 65·87 | 7·91 | 1387 | 878 | 35·3 | Indent 2 inches. |
| 544. | 6·5-inch plate ... | ,, | 16 | ,, | ,, | 65·87 | 7·91 | 1387 | 878 | 35·3 | Indent 1·6 inch. |
| 543. | 7·5-inch plate ... | ,, | 16 | ,, | ,, | 65·87 | 7·91 | 1387 | 878 | 35·3 | Indent 1·6 inch. |
| 545. | 5·5-inch plate ... | 7-inch B L rifled gun of 81 cwt. | 16 | ,, | Cylindrical cast-iron. | 65·94 | 6·9 | 1453 | 965 | 44·5 | Indent 1·9 inch. |
| 547. | 6·5-inch plate ... | ,, | 16 | ,, | ,, | 65·94 | 6·9 | 1453 | 965 | 44·5 | Indent 2·05 inches. |
| 546. | 7·5-inch plate ... | ,, | 16 | ,, | ,, | 65·94 | 6·9 | 1453 | 965 | 44·5 | Indent 1·65 inch. |
| 986. | 3-inch unbacked wrought-iron plate. | 12-pounder B L service gun of 8¼ cwt. | 1·5 | ,, | Cylindrical steel shot hemispherical-headed. | 12·62 | 2·9 | 1081 | 102·2 | 11·2 | Indent 2·3 inches. Struck 1 foot from top of plate; indent cracked; rear of plate cracked, starred, and bulged 2·5 inches. Shot very little cracked at head. Length 6·74 inches. |
| 989. | ,, | ,, | 1·5 | ,, | ,, | 12·62 | 2·9 | 1081 | 102·2 | 11·2 | *Through.* Struck 6 inches below 986. Clean hole through; shot rebounded; head of shot slightly cracked. Length |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 993. | „ | „ | 1·5 | Rifle L G | Cylindrical steel shot, hemispherical-headed. | 12·62 | 2·9 | 1081 | 102·2 | 11·2 | Indent 2·2 inches. Struck fair; indent not cracked; no mark in rear; shot slightly twisted and cracked at head. Length 6·5 inches. |
| 987. | 3·5-inch unbacked wrought-iron plate. | „ | 1·5 | „ | „ | 12·62 | 2·9 | 1081 | 102·2 | 11·2 | Indent 2·4 inches. Struck 1 foot from top and 3 inches from right edge; indent cracked; rear of plate cracked and a little bulged. Shot very little cracked at head. Length 6·8 inches. |
| 991. | „ | „ | 1·5 | „ | „ | 12·62 | 2·9 | 1081 | 102·2 | 11·2 | Indent 1·9 inch. Struck fair; rear cracked and slightly bulged 0·5 inch; indent cracked. Shot slightly cracked. |
| 995. | „ | „ | 1·5 | „ | „ | 12·62 | 2·9 | 1081 | 102·2 | 11·2 | Indent 2·1 inches. Struck fair; rear slightly cracked and bulged 0·4 inch; indent not cracked. Shot slightly cracked at head. Length 6·91 inches. |
| 998. | 4·5-inch unbacked wrought-iron plate. | „ | 1·5 | „ | „ | 12·62 | 2·9 | 1081 | 102·2 | 11·2 | Indent 1·95 inch. Struck fair in centre; indent not cracked; no crack or bulge in rear. Shot slightly twisted and cracked at head. Length 6·71 inches. |
| 992. | „ | „ | 1·5 | „ | „ | 12·62 | 2·9 | 1081 | 102·2 | 11·2 | Indent 1·6 inch. Struck fair; indent not cracked; no crack or bulge in rear Shot slightly twisted and cracked at head. Length 6·5 inches. |
| | 4½-inch unbacked plate. | Wall-piece. | drs. 10 | „ | Cylindrical steel shot, flat head. | 0·344 | 0·87 | 1141 | 3·1054 | 1·136 | Indent 0·2 inch. Shot rebounded 41 yards. |
| | „ | „ | 10 | „ | Ditto, round head. | 0·344 | 0·87 | 1141 | 3·1054 | 1·136 | Indent 0·6 inch. Shot rebounded 26 yards. |
| 492. | 4½-inch plate on Scott Russell target. | 12-pounder Armstrong B L gun. | lbs. 2 | „ | Cylindrical steel shot, flat head. | 11·15 | 2·9 | 1280 | 126·7 | 13·90 | Indent 1·05 inch. Shot rebounded 100 yards. |
| 493. | „ | „ | 2 | „ | Ditto, round head. | 11·15 | 2·9 | 1310 | 132·7 | 14·56 | Indent 2·1 inch. Shot rebounded 25 yards. |

TABLE XII.—(*continued*).

| No. of round. | Target. | Gun. | Charge. | | Projectile. | | | Striking-velocity. | $\frac{Wv^2}{2g}$ in foot-tons on impact. | Foot-tons per inch of shot's circumference. | Observed effects. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Weight. | Brand of Powder. | Nature and Length. | Weight. | Diam. | | | | |
| | | | lbs. | | | lbs. | inches. | feet. | | | |
| 494. | 4½-inch plate on Scott Russell target. | 12-pounder Whitworth B L gun. | 2 | Rifle L G | Cylindrical, steel shot, flat head. | 12·1 | 2·97<br>2·71 | 1350 | 153·0 | 16·71 | Indent 1·4 in., shot broke and rebounded 87 yards. |
| | | | drs. | | | | | | | | |
| | ¼-inch plate unbacked. | Wall-piece ..... | 10 | Rifle F G | „* | 0·344 | 0·87 | 1141 | 3·1054 | 1·136 | Through (mean of nine rounds). |
| | ½-inch plate unbacked. | „ | 10 | „ | „ | 0·344 | 0·87 | 1141 | 3·1054 | 1·136 | Through (mean of eight rounds). |
| | ¾-inch plate unbacked. | „ | 10 | „ | „ | 0·344 | 0·87 | 1141 | 3·1054 | 1·136 | Through (mean of six rounds). |
| | 1-inch plate unbacked. | „ | 10 | „ | „ | 0·344 | 0·87 | 1141 | 3·1054 | 1·136 | Indent 0·28 inch (mean of three rounds). |
| | 5-inch plate on Fairbairn target. | „ | 10 | „ | „ | 0·344 | 0·87 | 1141 | 3·1054 | 1·136 | Indent 0·25 inch (mean of two rounds). |
| | 4-inch plate on Mr. Roberts's target. | „ | 10 | „ | „ | 0·344 | 0·87 | 1141 | 3·1054 | 1·136 | Indent 0·25 inch (mean of two rounds). |
| | | | lbs. | | | | | | | | |
| 704. | 11-inch plate unbacked. | 13·3-inch M L gun of 23 tons. | 90 | Rifle L G | Spherical steel. | 344·4 | 13·24 | 1574 | 5916 | 142·2 | Struck centre of plate; indent 4·9 inches; broken in two and pieces thrown 6 feet apart. Shot much set up and cracked, rebounded 14 feet. |
| 1058. | 13-inch plate unbacked, forming left embrasure of experimental casemate. | 8-inch M L gun of 7 tons. | 22 | „ | Cylindrical steel. | 150·5 | 7·92 | 1270 | 1683 | 67·6 | Indent 3·55 inches; shot broke up. |
| 1059. | „ | 9·22-inch M L gun of 12 tons. | 30·25 | „ | „ | 222·0 | 9·15 | 1315 | 2662 | 92·6 | Indent 2·5 inches; plate cracked behind. Shot set up and cracked. |
| 1060. | „ | 10-inch M L gun of 12 tons. | 36·0 | „ | „ | 285·5 | 9·92 | 1195 | 2827 | 90·7 | Indent 2·8 inches; plate cracked behind. Shot set up and cracked. |
| 1056. | „ | 7-inch M L gun of 140 cwt. | 18·0 | „ | „ | 115·0 | 6·92 | 1330 | 1411 | 64·9 | Indent 3·1 inches. Shot set up and much cracked. |
| 1061. | Chalmers shield, or right embrasure of experimental casemate. | 10-inch M L gun of 12 tons. | 41·3 | „ | Cylindrical steel shot. | 282·0 | 9·92 | 1270 | 3154 | 101·2 | Indent 5·55 inches. Shot stuck in target, broke bolts and rivets, and bulged inner skin; shot cracked. |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1062. | ,, | ,, | 41·3 | ,, | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] outer plate [illegible] vertical plates; inner [illegible] cracked through. |
| 1063. | ,, | ,, | 41·3 | ,, | ,, | 282·0 | 9·92 | 1270 | 3154 | 101·2 | Indent 7·2 inches; bulged and cracked inner skin. Shot cracked. |
| 1051. | ,, | 7-inch M L gun of 140 cwt. | 18 | ,, | ,, | 116·25 | 6·92 | 1323 | 1411 | 64·9 | Indent 3·3 inches; shield forced back slightly; indent slightly cracked. Shot set up and cracked. |
| 1052. | ,, | 8-inch M L gun of 7 tons. | 22 | ,, | ,, | 151·0 | 7·92 | 1285 | 1676 | 67·3 | Indent 2·8 inches; shield forced back and slightly cracked. Shot set up and cracked. |
| 1053. | ,, | 9·22-inch M L gun of 12 tons. | 30·25 | ,, | ,, | 222·0 | 9·15 | 1315 | 2662 | 92·6 | Indent 3·7 in., and cracked; shield forced back slightly. Shot set up and cracked. |
| 1064. | ,, | ,, | 39·50 | ,, | ,, | 221·5 | 9·15 | 1400 | 3010 | 104·7 | Indent 5·65 inches; shot stuck in the plate; target bulged in rear and skin cracked. Shot set up and cracked. |
| 1055. | ,, | 10-inch M L gun of 12 tons. | 36·0 | ,, | ,, | 283·5 | 9·92 | 1267 | 3154 | 101·2 | Struck just below 1051. Indent 6·25 inches; broke many bolts and rivets, and buckled the outside plate. Shot set up and cracked. |
| 1000. | 5·5-inch plate unbacked in front of earth-butt. | 64-pounder M L gun of 140 cwt. (experimental). | 15·85 | ,, | Spherical steel shot. | 35·875 | 6·22 | 1920·0 | 917·0 | 46·93 | Through plate and into butt. |
| 1003. | ,, | ,, | 15·85 | ,, | ,, | 35·562 | 6·22 | 1925·0 | 913·8 | 46·76 | Through plate and into butt. |
| 1008. | ,, | ,, | 13·875 | ,, | ,, | 35·562 | 6·22 | 1829·0 | 824·9 | 42·21 | Just through; stuck in butt. |
| 1001. | ,, | ,, | 12·0 | ,, | Cylind. steel shot. | 63·687 | 6·22 | 1417·0 | 886·7 | 45·38 | Through plate and into butt. |
| 1006. | ,, | ,, | 12·0 | ,, | ,, | 71·25 | 6·22 | 1346·0 | 895·1 | 45·80 | Through plate and into butt. |
| 1009. | ,, | ,, | 10·50 | ,, | ,, | 70·875 | 6·22 | 1270·0 | 792·7 | 40·56 | Stuck in the plate; broke away plate behind. |
| 1002. | ,, | ,, | 11·219 | ,, | ,, | 106·625 | 6·22 | 1110·0 | 911·0 | 46·62 | Through plate and into butt. |
| 1007. | ,, | ,, | 11·219 | ,, | ,, | 106·812 | 6·22 | 1112·0 | 915·8 | 46·87 | Through plate and into butt. |
| 1010. | ,, | ,, | 9·81 | ,, | ,, | 106·562 | 6·22 | 996·0 | 733·0 | 37·50 | Stuck in the plate; point of shot showing through in rear. |
| 1011. | ,, | 100-pounder smooth-bore gun of 6½ tons. | 15·44 | L G | Spherical steel. | 104·125 | 8·87 | 1254·0 | 1135·4 | 40·65 | Through plate and into butt. |
| 1027. | ,, | ,, | 11·125 | ,, | ,, | 104·000 | 8·87 | 1135·0 | 929·0 | 33·34 | Indent 3·25 inches; plate bulged and cracked in rear. Shot rebounded. |
| 1012. | ,, | 7-inch M L gun of 134 cwt. | 11·625 | Rifle L G | Cylindrical steel. | 100·312 | 6·92 | 1004·0 | 701·1 | 32·25 | Indent 3·65 inches; plate bulged and cracked in rear. Shot rebounded. |
| 1013. | ,, | ,, | 11·625 | ,, | ,, | 100·125 | 6·92 | 1012·0 | 711·0 | 32·71 | Indent 4 inches; plate cracked and bulged in rear. Shot rebounded. |

TABLE XII. (*continued*).

| No. of round. | Target. | Gun. | Charge. | | Projectile. | | | Striking-velocity. | $\frac{Ws^2}{2g}$ in foot-tons on impact. | Foot-tons per inch of shot's circumference. | Observed effects. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Weight. | Brand of Powder. | Nature and Length. | Weight. | Diam. | | | | |
| | | | lbs. | | | lbs. | inches. | feet. | | | |
| 1026. | 5·5-inch plate unbacked in front of earth-butt. | 7-inch M L gun of 134 cwt. | 13·50 | Rifle L G | Cylindrical steel. | 100·312 | 6·92 | 1131·0 | 889·7 | 40·92 | Just through; shot fell in rear. |
| 1047. | 4·5-inch plate unbacked. | 64-pounder M L gun of 65 cwt. | 6·69 | ,, | Cylindrical steel shot. | 63·87 | 6·22 | 1112·2 | 547·8 | 28·03 | Just penetrated; shot rebounded. |
| 1158. | ,, | ,, | 6·63 | ,, | ,, | 63·87 | 6·22 | 1119·3 | 554·8 | 28·39 | Just penetrated; shot rebounded. |
| 1164. | ,, | ,, | 6·63? | ,, | ,, | 63·81 | 6·22 | 1098·2 | 533·6 | 27·31 | Indent 4·35 inches; almost penetrated. |
| 1160. | ,, | ,, | 6·09 | ,, | ,, | 106·19 | 6·22 | 860·5 | 545·2 | 27·90 | Just penetrated; shot fell inside at bottom of plate. |
| 1165. | ,, | ,, | 6·09 | ,, | ,, | 106·62 | 6·22 | 857·7 | 543·9 | 27·83 | Stuck in plate, head of shot showing through at back; almost penetrated. |
| 1166. | ,, | ,, | 6·09 | ,, | ,, | 106·62 | 6·22 | 859·5 | 546·2 | 27·95 | Through plate; shot stuck in earthwork behind. |
| 1162. | ,, | ,, | 8·0 | ,, | Spherical steel. | 35·56 | 6·22 | 1482·4 | 541·8 | 27·73 | Just penetrated; shot rebounded. |
| 1167. | ,, | ,, | 8·0 | ,, | ,, | 35·50 | 6·22 | 1484·9 | 542·8 | 27·78 | Clean hole through; shot remained in plate. |
| 1161. | ,, | ,, | 7·87 | ,, | ,, | 35·50 | 6·22 | 1460·0 | 524·7 | 26·85 | Stuck in plate; shot almost through. |

TABLE XIII.—Table giving the results of various Experiments with steel and other projectiles against structures protected by wrought-iron armour plates.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 'Warrior' ..... | 13·3-inch M L rifle gun of 23 tons. | 51·5 | Rifle L G | Steel shell*. | 612·5 | 13·24 | 938 | 3736 | 89·8 | Target completely penetrated, armour plate blown off, &c. Range 500 yards. |
| 723. | ,, | ,, | 70 | ,, | ,, | 612·5 | 13·24 | 1046 | 4649 | 111·7 | Target completely penetrated, with much damage. Range 1000 yards. |
| 498. | ,, | Horsfall's M L smooth-bore gun of 24 tons, calibre 13·014 inches. | 74·4 | L G | Spherical cast-iron shot. | 285 | 12·88 | 1290 | 3288 | 81·3 | Penetrated armour; shot lodged in the backing. Range 800 yards. |
| 497. | ,, | ,, | 74·4 | ,, | ,, | 279·5 | 12·80 | 1510 | 4420 | 109·9 | Target completely penetrated. |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| —6. | 'Warrior' ..... | 10·5-inch wrought-iron M L gun of 12 tons. | 50 | L G | Spher[illegible] cast-iron shot. | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | ing, bulging inner skin. (Transactions, p. 99, 1862.) |
| 934. | ,, | 7-inch wrought-iron rifled M L gun of 134 cwt. | 25 | Rifle L G | Cylindrical steel shot. | 100·00 | 6·91 | 1555 | 1677 | 77·2 | Target completely penetrated; shot picked up 44 yards in rear, after passing through a mound of sand. |
| 1018. | ,, | ,, | 20 | ,, | ,, | 99·56 | 6·91 | 1411 | 1374 | 63·2 | Target completely penetrated; shot went out to sea. |
| 1016. | ,, | ,, | 18 | ,, | ,, | 99·62 | 6·91 | 1340 | 1240 | 57·1 | Penetrated armour and lodged in the backing; inner skin not broken, but bulged slightly. |
| 943. | ,, | ,, | 17 | ,, | ,, | 100·00 | 6·91 | 1303 | 1177 | 54·2 | Penetrated armour, and lodged in the backing. |
| Not numbered. | ,, | 70-pounder M L Armstrong gun, "competitive." | 14 | ,, | ,, | 69·75 | 6·30 | 1550 | 1162 | 58·7 | Penetrated armour and lodged in backing, skin bulged and slightly cracked. (Transactions, p. 65, 1864.) |
| 935. | ,, | 7-inch M L gun of 134 cwt. | 25·0 | ,, | Cylindrical steel shot, hemispherical head. | 100·00 | 6·91 | 1531 | 1625 | 74·87 | Struck on a rib; target completely penetrated; shot went out to sea. |
| 936. | ,, | ,, | 25·0 | ,, | ,, | 100·00 | 6·91 | 1536 | 1636 | 75·36 | Struck between two ribs; target completely penetrated; shot broke up. |
| 937. | ,, | ,, | 25·0 | ,, | Cylindrical chilled shot, hemispherical head. | 104·00 | 6·89 | 1451 | 1518 | 70·14 | Penetrated armour plate and lodged in the backing; shot broke up. |
| 938. | ,, | ,, | 25·0 | ,, | ,, | 104·00 | 6·89 | 1473 | 1565 | 72·29 | Penetrated armour plate and lodged in the backing; shot broke up. |
| 939. | ,, | ,, | 25·0 | ,, | Ditto, elliptical head. | 101·00 | 6·89 | 1498 | 1572 | 72·6 | Struck between two ribs; target completely penetrated; shot broke up. |
| 940. | ,, | ,, | 25 | ,, | ,, | 102·00 | 6·89 | 1500 | 1591 | 73·5 | Target completely penetrated; shot broke up. |
| 945. | | ,, | 17 | ,, | ,, | 101·00 | 6·89 | 1282 | 1151 | 53·18 | Penetrated to a depth of 20 inches and broke up; no damage at back. |
| 943. | ,, | ,, | 17 | ,, | ,, | 101·00 | 6·89 | 1267 | 1124 | 51·94 | Struck partly on a rib, and penetrated to inner skin, which it cracked and bulged. |
| 944. | ,, | ,, | 17 | ,, | Cylindrical steel shot, hemisph. head. | 100·00 | 6·91 | 1300 | 1172 | 53·98 | Penetrated to a depth of 20 inches. Target weakened by 943. |

TABLE XIII.—(*continued*).

| No. of round. | Target. | Gun. | Charge. | | Projectile. | | | Striking-velocity. | $\frac{Ws^2}{2g}$ in foot-tons on impact. | Foot-tons per inch of shot's circumference. | Observed effects. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Weight. | Brand of Powder. | Nature and Length. | Weight. | Diam. | | | | |
| | | | lbs. | | | lbs. | inches. | feet. | | | |
| 946. | 'Warrior' ..... | 7-inch M L gun of 134 cwt. | 17 | Rifle L G | Cylindrical steel shot, hemispherical head. | 100·0 | 6·91 | 1297 | 1166 | 53·73 | Penetrated to a depth of 12·5 inches. Shot cracked. |
| 947. | " | " | 17 | " | " | 100·0 | 6·91 | 1297 | 1166 | 53·73 | Penetrated to a depth of 12·75 inches. Shot cracked. |
| 971. | " | " | 25 | " | Armstrong false-headed shell. (blind). | 97·5 | 6·92 | 1572 | 1670 | 76·9 | Struck fair, penetrated plate, forcing it into backing; shell stuck in plate. Head of shell bulged. Total indent about 9 inches. |
| 977. | " | " | 25 | " | Ditto (live). | 101·0 | 6·92 | 1544 | 1670 | 76·9 | Penetrated armour and burst in the backing; total depth of indent 17 inches. Skin slightly bulged. Target weakened by 975. |
| 978. | " | " | 25 | " | " | 101·0 | 6·92 | 1544 | 1670 | 76·9 | Struck fair, penetrated armour and burst in the backing. |
| [illegible] | " | 7-inch M L gun of 130 cwt. (Woolwich). | 25 | " | Alderson solid-headed shell (blind). | 98·0 | 6·92 | 1575 | 1686 | 77·5 | Struck fair, penetrated plate and lodged in the backing; total indent about 19 inches. |
| [illegible] | " | " | 25 | " | Ditto (live). | 102·62 | 6·92 | 1569 | 1685 | 77·5 | Struck fair; penetrated right through target, bursting in and setting fire to backing; solid head blown out to sea. |
| 983. | " | 7-inch wrought-iron rifled M L gun of 149 cwt. (Lancaster's). | 25 | " | Cylindrical steel shot, conoco- | 137·69 | 7·55 6·95 | 1418 | 1920 | 84·1 | Target completely penetrated. |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 990. | ,, | ,, | 17 | ,, | ,, | 137·31 | ,, | 1250 | 1417 | 43·1 | [illegible] |
| 512. | ,, | 7-in. wrought-iron rifled B L gun of 81 cwt. | 14 | ,, | ,, | 111·5 | 6·88 | 1097 | 930 | 43·0 | Penetrated armour, forcing it into backing; shot remained sticking in the plate. (Transactions, p. 154, 1863.) |
| 972. | ,, | 100-pounder S B (9-inch). | 25 | L G | Spherical steel shot, 'Firth.' | 105·0 | 8·87 | 1470 | 1573 | 56·4 | Struck between two ribs; penetrated armour and lodged in the backing; broke one rib and cracked another; inner skin cracked and bulged. Distance from face of plate to nearest part of shot 6·5 inches. |
| 979. | ,, | ,, | 9·75 | ,, | ,, | 104·0 | 8·87 | 930 | 624 | 22·4 | Shot rebounded; indent 1·7 in. Plate slightly bent; no injury to inner skin. |
| 736. | ,, | 68-pounder S B (8-inch). | 16·00 | ,, | Spherical steel shot. | 74·75 | 7·95 | 1362 | 962 | 38·5 | Shot stuck in the plate, which it penetrated and drove against backing; indent 4·8 inches (Trans. p. 70, 1864.) |
| 495. | 'Warrior' ..... | 7-inch Whitworth gun. | 23 | Rifle L G | Flat-headed steel shot. | 129·0 | 6·36<br>6·96 | 1270 | 1443 | 67·56 | Target penetrated to a depth of 13·5 inches. |
| Not numbered. | ,, | 7-inch, or 120-pounder, shunt gun. | 20 | ,, | Elongated cast-iron shot. | 140·0 | 6·9 | 1256 | 1531 | 70·65 | Total indent 3·1 inches, rib slightly bent. |
| ,, | ,, | 7-inch B L gun of 81 cwt. | 14 | ,, | ,, | 110·0 | 6·9 | 1140 | 991 | 45·72 | Total indent 1·6 inch. |
| ,, | ,, | ,, | 10 | ,, | ,, | 200·0 | 6·9 | 760 | 801 | 36·95 | Indent too small to be measured. Shot broke in two. |
| ,, | ,, | 68-pnder smooth-bore gun. | 16 | ,, | ,, | 66·5 | 7·91 | 1380 | 878 | 35·3 | Indent 2·5 inches. |
| ,, | 'Warrior,' with 5-inch armour. | 7-inch Whitworth gun. | 27 | ,, | Steel shell, flat-headed. | 151·0 | 6·36<br>6·96 | 1165 | 1421 | 66·52 | Completely penetrated; shell burst in backing, carrying many splinters inside. Range 800 yards. |
| ,, | ,, | ,, | 27 | ,, | ,, | 130·0 | 6·36<br>6·96 | 1238 | 1381· | 64·68 | Do. do. |
| 496. | 'Warrior' ..... | ,, | 27 | ,, | ,, | 130·0 | 6·36<br>6·96 | 1263 | 1438 | 67·35 | Do. do. Range 600 yards. |
| Not num. | 'Warrior,' with 5-inch armour. | 5-inch Whitworth gun. | 13 | ,, | ,, | 81·0 | 4·98<br>5·42 | 1102 | 682 | 40·35 | Penetrated armour, and burst in backing. |
| ,, | ,, | ,, | 13 | ,, | ,, | 72·5 | 4·98<br>5·42 | 1143 | 657 | 38·87 | Do. do. (Transactions, 1862, p. 86.) |
| 778. | 5·5-inch plate on 'Warrior' backing and skin. | 68-pounder smooth-bore (8-inch) of 95 cwt. | 16 | L G | Spherical steel. | 73·00 | 7·90 | 1355 | 930 | 37·45 | Indent 3·2 ins., and cracked. Shot cracked. |
| 779. | ,, | ,, | ,, | ,, | ,, | 72·50 | 7·88 | 1360 | 930 | 37·53 | Indent 3·25 ins., and cracked. Shot cracked. |

TABLE XIII. (*continued*).

| No. of round. | Target. | Gun. | Charge. | | Projectile. | | | Striking-velocity. | $\frac{Wv^2}{2g}$ in foot-tons on impact. | Foot-tons per inch of shot's circumference. | Observed effects. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Weight. | Brand of Powder. | Nature and length. | Weight. | Diam. | | | | |
| | | | lbs. | | | lbs. | inches. | feet. | | | |
| 780. | 5·5-inch plate on 'Warrior' backing and skin. | 68-pnder smooth-bore (8-inch) of 95 cwt. | 16 | L G | Spherical steel. | 73·00 | 7·90 | 1355 | 930 | 37·45 | Indent 3·8 inches, and cracked. Shot cracked. |
| 781. | ,, | ,, | 16 | ,, | ,, | 73·25 | 7·90 | 1353 | 930 | 37·45 | Indent 2·95 inches, do. Do. |
| 782. | ,, | ,, | 16 | ,, | ,, | 73·50 | 7·90 | 1351 | 930 | 37·45 | Indent 3·5 inches, do. Do. |
| 783. | ,, | ,, | 16 | ,, | ,, | 73·50 | 7·92 | 1354 | 935 | 37·6 | Indent 2·6 inches, and slightly cracked. Struck partly on bolt. Shot cracked. |
| 784. | ,, | ,, | 16 | ,, | ,, | 73·00 | 7·89 | 1355 | 930 | 37·52 | Indent 3·2ins., and cracked. Shot cracked. |
| 960. | 5-inch plate on backing of Chalmers target. | ,, | 16 | ,, | ,, | 73·25 | 7·91 | 1353 | 930 | 37·4 | Stuck in the plate, projecting 3 inches. Shot much cracked. Plate broken away behind. |
| 445. | 'Minotaur'..... | 10·5-inch wrought-iron M L gun of 12 tons. | 50 | ,, | Spherical cast-iron shot. | 150·00 | 10·37 | 1620 | 2730 | 83·8 | Penetrated armour and lodged in the backing, broke two ribs and seriously bulged the inner skin. (Transactions, p. 109, 1862.) |
| 446. | ,, | ,, | 50 | 2 A 4 | ,, | 150·00 | 10·37 | 1794 | 3347 | 102·7 | Target completely penetrated; shot passed clean through, carrying with it the piece of plate and many splinters. |
| 447. | ,, | ,, | 50 | ,, | ,, | 150·00 | 10·37 | 1794 | 3347 | 102·7 | Effects almost exactly similar to the previous round. |
| 448. | ,, | ,, | 50 | ,, | Spherical wrought-iron shot. | 162·0 | 10·37 | 1731 | 3366 | 103·3 | Shot set up and jammed itself in the plate; the target was tremendously shaken; backing cracked and skin bulged over a considerable area; two vertical ribs and numbers of bolts broken. |
| 718. | 'Bellerophon'..... | ,, | 35 | Rifle L G | Spherical steel shot. | 165·0 | 10·43 | 1470 | 2472 | 75·4 | Penetrated armour and remained in the backing; inner skin bulged and cracked. (Transactions, p. 196, 1863.) |
| 720. | ,, | 7-inch Whitworth gun. | 27 | ,, | Flat-headed steel shell | 149·5 | 6·36<br>6·96 | 1275 | 1685 | 78·92 | Penetrated armour, and burst in backing; inner skin bulged. |
| 717. | ,, | 10·5-inch M L gun of 12 tons. | 35 | L G | Spherical cast-iron shot. | 150·0 | 10·36 | 1547 | 2480 | 76·5 | Cracked and indented plate to a depth of 5 inches; skin slightly bulged (Transactions, 1863, p. 196.) |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| [illegible] | ,, | ,, | [illegible] | L G | ted cast-iron shot. | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 1·6 inch; skin slightly bulged. |
| 707. | ,, | 68-pnder smooth-bore gun. | 16 | L G | Spherical cast-iron shot. | 66·5 | 7·91 | 1380 | 878 | 35·3 | Total indent 1·5 inch; slight bulge on rear of plate. |
| 708. | ,, | 7-inch B L gun of 81 cwt. | 16 | Rifle L G | Elongated cast-iron shot. | 66·19 | 6·90 | 1450 | 965 | 44·5 | Total indent 1·2 inch; slight bulge on rear of plate. |
| 713. | ,, | ,, | 16 | ,, | ,, | 59·91 | 6·90 | 1524 | 965 | ,, | Total indent 1·8 inch; plate bulged behind. |
| 949. | 5·5-inch plate on backing and skin of 'Bellerophon' target. | 10·5-inch wrought-iron rifled M L gun of 12 tons. | 35 | L G | Spherical steel. | 165·5 | 10·36 | 1461 | 2450 | 75·1 | Struck near edge of plate; target completely penetrated; shot broke up. |
| 950. | ,, | ,, | 35 | ,, | ,, | 165·5 | 10·36 | 1461 | 2450 | 75·1 | Struck to right of 949, and passed completely through target. |
| 951. | ,, | 10·5-inch wrought-iron M L gun of 12 tons. | 35 | ,, | Spherical steel shot. | 165·5 | 10·36 | 1461 | 2450 | 75·1 | Struck low; shot penetrated to inner skin, which is bulged considerably; shot broke up. |
| 952. | ,, | ,, | 35 | ,, | ,, | 165·5 | 10·36 | 1461 | 2450 | 75·1 | Struck fair in the centre of the plate, and passed clean through the target. |
| 925. | ,, | 100-pnder smooth-bore gun (9-inch) of 6½ tons. | 25 | ,, | ,, | 104·0 | 8·86 | 1477 | 1573 | 56·5 | Broke through plate; shot remained sticking. Total indent about 7 inches. |
| 926. | ,, | ,, | 25 | ,, | ,, | 104·5 | 8·86 | 1473 | 1573 | 56·5 | Do. do. Do. |
| 927. | ,, | ,, | 25 | ,, | ,, | 104·0 | 8·86 | 1477 | 1573 | 56·5 | Do. Total indent about 8½ inches. |
| 928. | 5·5-inch plate on 'Belerophon' backing. | ,, | 25 | ,, | ,, | 104·5 | 8·86 | 1473 | 1573 | 56·5 | Broke through plate; shot remained sticking. Total indent about 7 inches. |
| 929. | ,, | ,, | 25 | ,, | ,, | 104·0 | 8·86 | 1477 | 1573 | 56·5 | Struck an old shot, sticking in plate; both projectiles were broken. |
| 915. | 'Bellerophon' backing, protected by 4·5-inch plate. | 68-pnder, 95 cwt. | 16 | ,, | Bessemer spherical steel shot. | 77·0 | 7·89 | 1320 | 930·0 | 37·5 | Clean hole through plate; half of shot remained in plate. |
| 916. | ,, | ,, | 16 | ,, | ,, | 76·5 | 7·89 | 1324 | 930·0 | 37·5 | Broke through plate; shot remained sticking, and much cracked. |
| 918. | ,, | ,, | 16 | ,, | ,, | 76·5 | 7·89 | 1324 | 930·0 | 37·5 | Broke through plate; shot remained sticking; cracked. |
| 919. | ,, | ,, | 16 | ,, | ,, | 76·75 | 7·89 | 1322 | 930·0 | 37·5 | Broke through plate and remained sticking; rear half of shot broke off. |

TABLE XIII. (*continued*).

| No. of round. | Target. | Gun. | Charge. | | Projectile. | | | Striking-velocity. | $\frac{Wv^2}{2g}$ in foot-tons on impact. | Foot-tons per inch of shot's circumference. | Observed effects. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Weight. | Brand of Powder. | Nature and length. | Weight. | Diam. | | | | |
| | | | lbs. | | | lbs. | inches. | feet. | | | |
| 917. | 'Bellerophon' backing, protected by 5·5-inch plate. | 68-pnder, 95 cwt. | 16 | L G | Bessemer spherical steel shot. | 76·5 | 7·89 | 1324 | 930·0 | 37·5 | Indent 3 inches. Shot rebounded, much cracked; indent cracked; plate cracked behind. |
| 920. | ,, | ,, | 16 | ,, | ,, | 76·37 | 7·89 | 1325 | 930·0 | 37·5 | Indent 3·55 inches, and cracked; shot much cracked; plate cracked behind. |
| 921. | ,, | ,, | 16 | ,, | ,, | 77·0 | 7·89 | 1320 | 930·0 | 37·5 | Indent 3 inches, and cracked all round; shot much cracked; plate cracked behind. |
| 922. | ,, | ,, | 16 | ,, | ,, | 77·0 | 7·89 | 1320 | 930·0 | 37·5 | Indent 4 inches, and cracked; shot stuck in the plate; shot much cracked, and plate cracked behind. |
| 923. | ,, | ,, | 16 | ,, | ,, | 77·0 | 7·89 | 1320 | 930·0 | 37·5 | Indent 6·8 inches. Piece of plate broken out at back; shot slightly cracked; weak part. |
| 924. | 5·5-inch, unbacked. | ,, | 16 | ,, | ,, | 76·56 | 7·89 | 1323 | 930·0 | 37·5 | Struck an old hole, and passed through. |
| 806. | 'Lord Warden.'... | 10·5-inch wrought-iron M L gun of 12 tons. | 50 | Rifle L G | Spherical steel shot. | 168·25 | 10·43 | 1576 | 2898 | 88·4 | Penetrated armour plate; hole 11·5×11 inches; shot broke through inner skin and buried itself in ship's timbers; back shaken. (Transactions, p. 96, 1864.) |
| 810. | ,, | ,, | 45 | ,, | Cylindrical steel shot. | 301·0 | 10·46 | 1250 | 3261 | 99·2 | Target completely penetrated. (Transactions, p. 95, 1864.) |
| 807. | ,, | 9·22-inch wrought-iron rifled M L gun of 12 tons. | 44 | ,, | ,, | 221·0 | 9·14 | 1450 | 3222 | 112·2 | Target completely penetrated; shot went 500 yards out to sea. (Transactions, p. 96, 1864.) |
| 813. | ,, | ,, | 30 | ,, | ,, | 222·0 | 9·14 | 1310 | 2642 | 92·0 | Target completely penetrated. (Transactions, p. 98, 1864.) |
| 803. | ,, | 9·22-inch wrought-iron rifled M L gun of 6½ tons. | 25 | ,, | Spherical steel shot. | 114·25 | 9·14 | 1424 | 1606 | 55·9 | Armour penetrated; shot lodged in the backing. (Transactions, p. 96, 1864.) |
| 808. | ,, | ,, | 25 | ,, | Spherical chilled cast-iron shot. | 103·75 | 9·17 | 1507 | 1634 | 56·7 | Broke armour plate, and forced it into backing; cracked lower plate; shot broke up. (Transactions p. 96, 1864.) |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| [illegible] | | 7-in. wrought-iron rifled M L gun of 134 cwt. | 25 | „ | Cylindrical steel shot. | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | the inner plate, from which it deflected and passed out at the top of the target. (Transactions, p. 96, 1864.) |
| 802. | „ | 68-pounder SB (8-inch). | 16 | L G | Spherical steel shot. | 71·4 | 7·94 | 1394 | 962 | 38·5 | Shot rebounded; indent 3·6 inches, and cracked all round; shot broke in two. (Transactions, p. 96, 1864.) |
| 846. | Small Plate (5·9-inch plate). | 10·5-inch wrought-iron M L gun of 12 tons. | 50 | Rifle L G | „ | 168·25 | 10·43 | 1576 | 2398 | 88·4 | Target completely penetrated. (Transactions, p. 102, 1864.) |
| 850. | Do. (4·75-in. plate). | „ | 22·5 | „ | „ | 166·0 | 10·43 | 1200 | 1657 | 50·6 | Through target, which had, however, been already considerably shaken. (Transactions, p. 102, 1864.) |
| 853. | Do. (5·9-in. plate). | „ | 35 | „ | Cylindrical steel shot. | 297·0 | 10·46 | 1105 | 2514 | 76·5 | Target completely penetrated. (Transactions, p. 104, 1864.) |
| 845. | Do. (4·75-in. plate). | 9·22-inch wrought-iron rifled M L gun of 12 tons. | 44 | „ | Cylindrical chilled cast-iron shot. | 258·12 | 9·14 | 1375 | 3384 | 117·8 | Target completely penetrated; massive knee detached, and driven 16 feet to rear; shot broke up. (Transactions, p. 102, 1864.) |
| 852. | Do. (5·9-in. plate). | „ | 30 | „ | Cylindrical steel shot. | 222·0 | 9·14 | 1310 | 2642 | 92·0 | Target completely penetrated; backing much shattered; strong timber support cut in two; shot struck against Scott Russell target behind. (Transactions, p. 102, 1864.) |
| 997. | „ | 9·22-inch M L gun of 6¼ tons. | 25 | L G | Spherical steel shot. | 113·50 | 9·15 | 1452 | 1659 | 57·7 | Penetrated the plate, driving it into backing; total indent about 10 inches (subsequently a chilled shot had the same effect, round 999). |
| 855. | Do. (4·75-in. plate). | 9·22-inch wrought-iron rifled M L gun of 12 tons. | 30 | Rifle L G | Cylindrical chilled cast-iron shot. | 259·0 | 9·14 | 1222 | 2682 | 93·4 | Target completely penetrated; massive knee detached and driven 8 feet to rear; shot broke up. (Transactions, p. 104, 1864.) |
| 843. | „ | 7-inch wrought-iron rifled B L gun of 81 cwt. | 12 | „ | Cylindrical steel shot. | 110·9 | 6·88 | 1090 | 914 | 42·3 | Penetrated armour, forcing it into back; shot remained sticking in plate. |
| 848. | Do. (5·9-in. plate). | „ | 12 | „ | „ | 110·9 | 6·88 | 1090 | 914 | 42·3 | Indented plate to a depth of 2·8 inches; circumference of indent cracked; plate cracked at back. |
| 842. | Do. (4·75-in. plate). | 68-pnder smooth-bore (8-inch). | 16 | L G | Spherical steel shot. | 73·80 | 7·94 | 1371 | 962 | 38·5 | Penetrated armour, driving the piece into the backing; depth of indent 5·7 inches. (Transactions, p. 102, 1864.) |

TABLE XIII. (*continued*).

| No. of round. | Target. | Gun. | Charge. | | Projectile. | | | Striking-velocity. | $\frac{Wv^2}{2g}$ in foot-tons on impact. | Foot-tons per inch of shot's circumference. | Observed effects. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Weight. | Brand of powder. | Nature and length. | Weight. | Diam. | | | | |
| | | | lbs. | | | lbs. | ins. | feet. | | | |
| 847. | Small Plate (5·9-inch plate). | 68-pnder smooth-bore. | 16 | L G | Spherical steel shot. | 73·80 | 7·94 | 1371 | 962 | 38·5 | Indent 3·9 inches, and cracked round bottom. (Transactions, p. 106, 1864.) |
| 840. | ,, | ,, | 16 | ,, | Spherical cast-iron shot. | 66·25 | 7·91 | 1382 | 878 | 35·3 | Indent about 2·2 inches. |
| 841. | ,, | 7-inch rifled B L of 81 cwt. | 12 | Rifle L G | Elongated cast-iron shot, 12·3 in. | 111·0 | 6·90 | 1090 | 914 | 42·2 | Indent 1·7 inch. |
| 851. | Do. 5·9-inch and 4·75-inch. | 10·5-inch M L gun of 12 tons. | 35 | ,, | Do. 15·5 in. | 296·0 | 10·36 | 1100 | 2483 | 76·3 | Struck on junction of two plates; broke in armour; total indent 10·5 inches. |
| 1141. | 'Hercules'* (8-in. plate). | 13-inch M L rifled gun of 22 tons. | 100 | ,, | Cylindrical steel shot. | 573·0 | 12·94 | 1268 | 6388 | 157·0 | Struck 8-inch plate on rib; shot stuck in plate, forcing the pieces into the backing; indent about 13 inches; inner skin slightly bulged; two ribs cracked. |
| 1142. | ,, | ,, | 100 | ,, | ,, | 574·0 | 12·94 | 1276 | 6480 | 159·4 | Struck 8-inch plate between two ribs; damage much the same as 1141. |
| 1144. | ,, | ,, | 100 | ,, | Chilled shot, Ogival head. | 577·5 | 12·95 | 1310 | 6872 | 169·0 | Struck 8-inch plate just above 1142, and passed through the target. This hit was hardly a fair one, as the plate was weakened by 1142. Shot broken up. |
| 1145. | ,, | ,, | 100 | ,, | ,, | 580·5 | 12·95 | 1307 | 6872 | 169·0 | Struck on 8-inch plate, partly on rib, and penetrated to a depth of 22 inches. Shot broke up in the hole. This shot appeared, from its fracture, to have been cracked in the process of chilling. |
| 1041. | ,, | 10·5-inch M L rifled gun of 12 tons. | 45 | ,, | Cylindrical steel shot. | 299·8 | 10·42 | 1277 | 3390 | 103·6 | Penetrated the plate, driving it into the backing, and slightly bulging the ¾-inch inner iron plate. Shot rebounded; indent 13 inches. |
| 1043. | 'Hercules' (9-inch plate). | ,, | 45 | ,, | ,, | 299·8 | 10·42 | 1283 | 3422 | 104·5 | Struck partly on a bolt, just below 1042; indent 8·27 inches; plate weakened by 1042. |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| [illegible] | .. | .. | 60 | .. | .. | 206·8 | 10·42 | 1425 | 4221 | 138·0 | [illegible] indent 6·1 inches; shot set up 2 inches, and cracked; diameter of indent 12·75 inches. |
| 1045. | Do. 8-inch plate... | 10-inch M L rifled gun of 12 tons. | 55 | „ | „ | 282·0 | 9·92 | 1400 | 3833 | 123·0 | Struck between two ribs on a bolt; penetrated plate, forcing it into the backing. |
| 1040. | Do. 9-inch plate... | 9·22-inch M L rifled gun of 12 tons. | 44 | „ | „ | 221·5 | 9·15 | 1452 | 3238 | 112·6 | Stuck in plate; indent 4·5 inches; plate buckled 1 inch; piece of plate nearly dislodged; plate and shot cracked. |
| 1042. | „ | „ | 44 | „ | „ | 221·5 | 9·15 | 1451 | 3234 | 112·5 | Indent 4·35 inches; other effect similar to round 1040; shot set up. |
| 590. | Chalmers..... | 10·5-inch wrought-iron M L gun of 12 tons. | 45 | „ | „ | 301·0 | 10·46 | 1250 | 3261 | 99·2 | Target completely penetrated. (Transactions, p. 184, 1863.) |
| 613. | Clarke ..... | „ | 50 | L G | Spherical steel shot. | 166·0 | 10·43 | 1587 | 2898 | 88·4 | Target completely penetrated. (Transactions, p. 191, 1863.) |
| 591. | Chalmers..... | „ | 50 | „ | Spherical cast-iron shot. | 149·62 | 10·37 | 1622 | 2730 | 83·8 | Penetrated armour and lodged in backing; total indent 11 inches; shot broke up. |
| 592. | „ | „ | 50 | „ | „ | 149·62 | 10·37 | 1622 | 2730 | 83·8 | Do.; total indent 12 inches. |
| 548. | 7·5-inch target..... | 10·5-inch M L gun of 12 tons. | 45 | Rifle L G | Cylindrical steel shot. | 301 | 10·45 | 1285 | 3446 | 104·9 | Struck on a rib; indent 6·2 inches; broke in plate over a diameter of 12·9 inches; backing and inner frame considerably shaken; shot set up 2·5 inches. (Transactions, p. 174, 1863.) |
| 553. | „ | 9-inch M L gun of 16 tons, rifled on Mr. Thomas's system. | 50 | „ | „ | 330 | 8·98 | 1220 | 3406 | 120·7 | Struck on bolt; indent 7·5 inches; broke in plate over a diameter of 12·5 inches; considerable damage in rear; inner skin bulged and fractured; shot broke in two. (Transactions, p. 174, 1863.) |
| 771. | 6·5-in. target (Box) | 13·3-inch M L gun of 23 tons. | 70·0 | „ | „ | 603 | 13·24 | 1136 | 5396 | 129·7 | Target completely penetrated; shot struck and indented the supporting target behind; shot set up 2·2 inches. (Transactions, p. 86, 1864.) |
| 825. | „ | „ | 40·0 | „ | „ | 603 | 13·24 | 859 | 3085 | 74·2 | Penetrated the armour and shattered the backing; bulged and cracked inner skin and ribs; shot set up 1 inch. (Transactions, p. 86, 1864.) |
| 1. | 'Portsmouth,' A... | 9·22-inch wrought-iron smooth-bore M L gun of 6½ tons. | 25 | „ | Spherical steel shot, "Firth." | 113·81 | 9·15 | 1450 | 1659 | 57·7 | Penetrated 5·5-inch plate and ship's side. (Transactions, p. 54, 1864.) |

TABLE XIII. (*continued*).

| No. of round. | Target. | Gun. | Charge. | | Projectile. | | | Striking-velocity. | $\frac{Wv^2}{2g}$ in foot-tons on impact. | Foot-tons per inch of shot's circumference. | Observed effects. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Weight. | Brand of Powder. | Nature and length. | Weight. | Diam. | | | | |
| | | | lbs. | | | lbs. | inches. | feet. | | | |
| Not numbered. | 'Portsmouth' B. | 9·22-inch wrought-iron smooth-bore M L gun of 6½ tons. | 25 | L G | Spherical steel shot. "Firth." | 114·00 | 9·15 | 1449 | 1659 | 57·7 | Penetrated 6-inch armour plate, driving piece into ship's side; exterior of shot 2·7 inches from surface of plate, planking in rear forced inward about 3·5 inches. Shot cracked. (Transactions, p. 61, 1864.) |
| ,, | ,, | ,, | 30 | ,, | ,, | 114·00 | 9·15 | 1515 | 1814 | 63·1 | Penetrated 6-inch armour plate, driving piece into ship's side; exterior of shot ½ inch from surface of plate; planking in rear, 16 feet by 4 feet, driven back 5 inches. Shot cracked. (Transactions, p. 61, 1864.) |
| ,, | 'Portsmouth' C... | 68-pounder smooth-bore. | 16 | ,, | Spherical steel shot. | 74·09 | 7·94 | 1368 | 962 | 38·5 | Penetrated the 4·5-inch plate, and lodged in ship's side; surface of shot projecting about 1 inch from face of plate; plank in wake of impact started and broken. Shot cracked. (Transactions, p. 55, 1864.) |
| ,, | 'Portsmouth' A. | ,, | 16 | ,, | ,, | 73·00 | 7·94 | 1379 | 962 | 38·5 | Stuck in plate; surface of shot projecting about 4 inches from face of plate. Shot cracked. (Transactions, p. 60, 1864.) |
| ,, | 9-inch plate backed by 42 inches of wood. | 8-inch M L rifled gun of 7 tons. | 30 | Rifle L G | Cylindrical steel shot. | 150·0 | 7·92 | 1420 | 2097 | 84·3 | Indent 3·2 inches; back of plate bulged and slightly cracked; shot set up, and cracked at head*. |
| ,, | 6-inch plate backed by 42 inches of wood. | 68-pnder smooth bore of 95 cwt. | 16 | L G | Spherical chilled shot. | 69·0 | 7·92 | 1381 | 935 | 36·7 | Indent 3·2 inches; plate bulged and slightly cracked at back; broken part of shot stuck in plate*. |
| ,, | 'Warrior' ..... | 7-inch B L rifled gun of 81 cwt. | 23 | 2a 4 | Hemispherical-headed elongated steel shot, 9 inches. | 79·0 | 6·9 | 1573 | 1355·4 | 62·5 | Struck near an old hole; shot passed through the target in a broken state. |
| ,, | ,, | ,, | 22 | Rifle L G | ,, | 80·0 | 6·9 | 1404 | 1003·5 | 30·4 | Passed through top plate, where only partly backed, and went to sea. |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ,, | ,, | ,, | 22 | ,, | ,, | 80·0 | 6·9 | 1404 | 1093·5 | 50·4 | Struck fair on bottom plate; penetrated to a depth of about 21 inches; inner skin uninjured. |
| ,, | ,, | ,, | 23 | ,, | ,, | 80·0 | 6·9 | 1438 | 1147·1 | 52·9 | Struck fair; penetrated to a depth of about 19 inches; shot broke up; inner skin uninjured. |
| ,, | ,, | ,, | 21 | ,, | Elongated* steel shell 14·5 inches. | 80·0 | 6·9 | 1356 | 990 | 45·7 | Penetrated armour plate, and burst in the backing; no damage behind. |
| ,, | ,, | ,, | 21 | ,, | ,, | 80·0 | 6·9 | 1318 | 964 | 44·5<br>53·3 | Do. do. |
| ,, | 'Fairbairn' ..... | ,, | 18 | ,, | 13·5 ins. | 78·0 | 6·9 | Not observed. | Not observed. | Not observed. | Fired blind; punched a hole in the armour plate, but did not force the piece of plate through the skin. |
| ,, | ,, | ,, | 17 | ,, | 14·5 ins. | 91·5 | 6·9 | ,, | ,, | ,, | Fired blind; completely penetrated the target. |
| ,, | ,, | ,, | 17 | ,, | 13·5 ins. | 78·0 | 6·9 | ,, | ,, | ,, | Fired blind; indent 3·5 inches. |

* Armstrong pattern.

## *Report on Isomerism among the Alcohols.* *By* J. A. Wanklyn.

The author recognized the necessity of obtaining normal or $\alpha$ alcohols in order to be able to form a just estimate of the influence of abnormal structure on the properties of the alcohols and their derivatives. At the present moment it actually seems to be easier to obtain an abnormal than a completely normal alcohol.

An attempt was made to obtain normal propylic alcohol by synthesis. The method of Mendius was adopted. No difficulty was experienced in getting cyanide of ethyl transformed into propylamine by the addition of nascent hydrogen from zinc and dilute sulphuric acid. But on attempting to transform propylamine into nitrite of propyl, as according to the researches of Hofman should be possible, the process came to a standstill. This method of synthesis, which is given in the books as a cardinal fact, does not answer as a method of ascending the alcoholic series. The experiments were made by the author and Mr. Chapman.

*Report of the Committee on Scientific Evidence in Courts of Law, consisting of the* Rev. W. V. HARCOURT, Professor WILLIAMSON, the Right Hon. J. NAPIER, Mr. W. TITE, Professor CHRISTISON, Mr. CARPMAEL, Dr. TYNDALL, Mr. JAMES HEYWOOD, Mr. J. F. BATEMAN, Mr. THOMAS WEBSTER, Sir BENJAMIN BRODIE, *Bart., and* Professor W. A. MILLER: Professor WILLIAMSON, *Secretary.*

IN the year 1862 a Committee of this Association recommended that "By a Legislative Act judges should be empowered, on application from a suitor, in causes of a technical character, to convene skilled assessors, the number of whom should not exceed three, and who should give their opinions truly on the statements of the witnesses in such manner as they shall be required by the judge previous to his adjudication of the cause." No legislative action has, however, as yet been taken upon this recommendation.

It is admitted that the character and functions of one class of witnesses have of late years undergone an important development, which has removed them from the position of ordinary witnesses. Yet no provision has as yet been made for this alteration, and the new witnesses are in the eyes of the law still like other witnesses. These new witnesses may be described as active witnesses; for the novelty in their functions consists in the practice of collecting by active exertions facts which are favourable to one conclusion upon the question at issue, and even making experimental researches for the discovery of new facts which may be favourable to that side. An impartial witness goes into court to depose to such facts as he may know pertaining to the question under investigation, and he is bound to state those facts in as accurate and straightforward a manner as possible, and to avoid shaping his statements with a view of promoting one conclusion or verdict more than another. But an active witness, when he undertakes to give evidence upon any question, need not be possessed of any specific information bearing upon the question at issue. He receives statements and information from persons who are interested in one particular conclusion, and he receives no information from the opposite party. But with his mind thus prepared with facts on one side of the question, he frequently sets to work to verify these facts experimentally, or to find new facts bearing upon the question at issue. His opportunities of collecting facts for the trial are one-sided, and his facts are mainly in favour of one particular view of the case—the view which he has been employed to support. So well is this partiality of the evidence of scientific witnesses felt and acknowledged, that the more conscientious witnesses, and probably most scientific witnesses, would decline to give evidence at the request of a party whose case they considered unjust. They know that their efforts would tend to increase his chances of success, and they decline to promote a cause which they consider unjust. By thus acting, these conscientious witnesses usurp the functions of judge; for they decide the case in their own minds, and either strive to carry out what they consider a just conclusion, or refuse to aid what they consider an unjust one. If his position in a trial were not of necessity one-sided, and if he did not consider himself bound to support the side upon which he is employed, a scientific or active witness would have no motive for forming an opinion upon the subject at issue before consenting to give evidence. His very selection of what seems the true side is a proof that he is aware of being necessarily partial. With our present procedure, every scientific witness must either allow chance to decide which side he will aid by his exertions, or else he must prejudge in his own mind the question at issue, and then strive to carry

out this verdict by exerting his energies on behalf of the conclusion which he considers true. He is compelled to be a partisan, and tries to avoid being the partisan of falsehood. It is asserted that for the ends of justice such conflicts of evidence as are thus obtained between witnesses engaged by the opposite parties ought to take place; but no reason has been shown why such partial witnesses should be placed in the position of impartial witnesses, or why there should not be scientific witnesses so placed as to have as little bias as possible, and able to depose to facts which they know to be true, leaving to others to weigh these against the opposite facts, and to decide the question at issue upon the result of such comparison.

The present system oscillates between two evils, according as the depositions of scientific witnesses are received by the court. If received as impartial depositions, they endanger the cause of truth; and if considered partial, they are liable to bring censure upon the so-called witnesses who make the depositions.

Among the various remedies for these evils which have been suggested, the two following appear to your Committee most promising:—

One remedy would consist in the appointment by the judge of some scientific witnesses in addition to the witnesses engaged by each party respectively in the suit. These judicial witnesses would hear the evidence adduced on each side, and would be empowered to request the witnesses on each side to show them the experimental or other proofs of their statements, and they would report to the Court all important corrections of statements made by the partial witnesses which they might be able to make, as well as all other facts of which they might be cognizant, bearing upon the question at issue.

The functions of these judicial witnesses would, however, be confined to statements of particulars of evidence. They would have no concern with questions of law, and would accordingly be precluded from summing up the particulars of evidence in favour of any conclusion, unless called upon by the judge to sum up any part of the evidence. The presence of these judicial witnesses could not fail to act as a check upon the statements of partial witnesses.

The other form of remedy would consist in the appointment by the judge of assessors competent to advise him respecting the evidence adduced by the ordinary witnesses.

The Committee is of opinion that the vast extension of natural knowledge which has taken place of late years, and the corresponding development of manufacturing processes, have necessitated the consultation in courts of law of men cognizant of the principles involved in any processes under consideration, and skilled in the art of eliciting information upon them by experiments; but they are of opinion that the action of such persons requires some check of the kind above described.

They trust that the Legislature may soon give to the subject that attention which it so urgently demands.

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[*The Report on the Standard of Electrical Resistances*, with Dr. JOULE's Paper (referred to in the Transactions of the Sections, p. 12), will appear in the next volume.]

## *Second Report on Maltese Fossiliferous Caves &c.*

*By* A. LEITH ADAMS, *M.A., M.B., F.G.S.*

THE Report I had the honour to lay before the Members of this Section at the last Meeting of the Association contained a summary of my researches and discoveries in connexion with the fossiliferous caves, fissures, and alluvial deposits of the Maltese Islands, but had more especially reference to the contents of the Mnaidra Cave, which was then only partially explored. Since that period I have been enabled to clear out the above remarkably productive locality, and continue previous researches in other situations, and bring together a large assemblage of fossil remains, which have been duly forwarded to the Committee appointed to report on the excavations, together with a detailed account of them, as far as I have been able to determine.

Early in December 1865 the explorations in Mnaidra Cave were recommenced, at the point where they terminated (as stated in my last Report); and they were continued with unabated vigour until the entire *débris* and fossiliferous remains were removed and attentively examined. Then the exact nature of the opening and mode of deposition of its contents became apparent.

(1) *Mnaidra Gap.*—Mnaidra, like similar gaps and fissures throughout the islands, had at first sight the appearance of a cave; but when attentively examined afterwards, was found to present several roof-openings by which its contents had been conveyed into the interior. It was therefore a simple gap or hollow depression, covered in here and there by fragments of the parent rock and stalactite. Its greatest length was 100 feet, the breadth varying from 15 to 40 feet; its eastern side and rounded extremity were smooth and upright, inclining slightly inwards, whilst the western or opposite side sloped at an angle of about 50°, thus contracting the breadth of the cavity to about 15 feet at the lower limits of the fossiliferous deposits, which lay for the most part along the eastern wall. The lowermost deposits described in my last Report continued much the same to the limits of the gap, and showed no traces of organic remains. The brick-red clay on which the fossiliferous deposit rested, was found to thin out towards the extremity, and slope gradually downwards at a low angle to about the middle of the gap, where it deepened and spread out towards the entrance on the edge of the cliff. Precisely the same colour pervaded the overlying *débris* in which the animal remains were distributed, the largest accumulation of bones being found at the bottom of the incline—that is, about the middle of the gap, where the second series of explorations were begun in December 1865. Nor was there any material change in the nature of the fossiliferous deposits: the same thin stratum of sandstone pebbles, with teeth and fragments of bones of the quadrupeds and birds, continued on to the furthest extremity of the gap, and overlay the brick-red clay, succeeded by the red and blue clay, intermixed with large blocks of sandstone—the fossil remains being found in the greatest abundance, and in the best state of preservation, wherever the stones and clay predominated. The greatest thickness of the two latter equalled 10 feet, but the average was not above 6 feet. The superficial white calcareous drift on the top attained a depth of 9 feet in certain situations, with angular fragments of sandstone and the parent rock intermixed. This deposit showed all the appearances of its having been derived from the degradation of the two last-named formations, and was probably conveyed into the gap by the same agency that brought the stones and clay, as teeth, tusks, and bones of elephant, and remains of the large dormouse, also land shells, were found here and there throughout, even to within a foot of the surface. Thus the maximum thickness of the fossiliferous deposit equalled 18 feet. It

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filled the cavity in the shape of a talus, narrowing at the upper and inner extremity, and spreading outwards towards the entrance. There were, therefore, three distinct kinds of arrangement of the fossiliferous deposits:—1st. When water passed down its floor, bearing along with it small pebbles and fragments and bones of teeth of the proboscidian, rodent, birds, and shells. 2nd. A sudden rush of water containing blocks of sandstone from the slope above, soil, and portions or whole carcasses of the animals just mentioned, and, finally, the scourings of the rock-surfaces and whatever organic remains and *débris* were lying thereon. The mode of arrangement of the deposits indicated that they had been borne down the west and north sides, from the circumstance that the *débris* and remains were piled up pell-mell along the concave eastern wall, the most perfect remains being found near the inner extremity of the gap, whilst fragments of bones increased towards the entrance. On the slope above, in the direction just indicated, were discovered several sandstone blocks lying in the pot-holes and waterworn crevices of the lower limestone, as if they had been deposited there at the same time that the masses were carried into the gap. Although many bones, especially those of the feet, showed every appearance of having being introduced in the flesh, there were not a few that testified by their cracked exterior and surface-decay, that they had been bleaching in the open air before they were conveyed into the gap. At all events the organic remains could not have been brought from any great distance, as is exemplified by the perfect state of preservation of the majority of the teeth and bones of the proboscidian. In my last Report I estimated that remains of upwards of fifty individual elephants had been identified up to the termination of the first series of explorations; since then more than 100 elephants' teeth alone have been added to the above, besides many important bones of the skeleton. The remains of the gigantic dormouse, more especially at the upper extremity of the gap, were so numerous that there was scarcely a square inch of the lower stratum that did not contain abundant relics of this rodent.

(2) *Gandia Fissure.*—The phenomena represented by the Mnaidra gap were again repeated inland in an ossiferous fissure in the calcareous sandstone in the district of Gandia, three miles to the east. Here during the summer of 1865 I cleared out a gaping rent, communicating with the surface, and filled to the depth of 8 feet with red earth and masses of the parent rock, among which were discovered teeth of upwards of sixteen individual elephants, of nearly all ages, together with bones of the rodent, and those of water-birds, including species of very large proportions, as evinced by the length and dimensions of the articulating surfaces of the bones—the breadth across the condyles of one femur being 2 inches. It is worthy of note that all the ossiferous cavities and deposits hitherto discovered in the Maltese Islands have been either in the downcast or denuded districts. The latter embrace nearly two-thirds of the island of Malta, viz. the whole of that portion eastward of a line passing about N. and S. through Civita Vecchia. It is computed that a thickness of from 400 to 500 feet of limestone, sand, marl, and sandstone has entirely disappeared from the above locality. In some places the sandstone has been entirely denuded, bringing into view the lower limestone, which, from its hardness, has retained the traces of sea-action on its surface.

(3) *St. Leonardo Fissure.*—Another example of a similar description to the two last described was afforded by the contents of St. Leonardo Fissure, situated in the calcareous sandstone on the N.E. coast of Malta, and close to the sea, which, however, had washed away the greater portion of the contents before my attention was directed to the locality. Here, under precisely the same conditions as just mentioned, I discovered teeth and fragments of a skeleton of a young elephant. Such accumulations, either with or without organic

remains, are common throughout the denuded district, displaying in every instance the same pell-mell arrangement of their contents.

(4) *Benghira Gap.*—At the S.E. extremity of Malta, and five miles from Mnaidra Gap, in the calcareous sandstone, is situated a little gorge, forming an inlet up which the sea penetrates for 700 feet to the base of an accumulation of stratified blocks of sandstone and red soil, which fill the further end of the gap, and extend inwards for several hundred feet. My attention was directed to this spot during the winter months of 1864, in consequence of observing several elephants' teeth and bones lying among the *débris*. The sides of this hollow incline at angles of 45°, embracing between them a surface breadth of 110 feet of alluvial deposit, the maximum height being 32 feet. An entire section of this gap displays the following appearances:—A layer of large partially waterworn blocks of sandstone, derived from the pale variety in which the gap is formed, occupies several feet of the bottom, mixed up pell-mell with red soil and silt, derived from disintegrated fragments of the same sandstone. Superimposed on the mass is a layer of gravel and much waterworn pebbles of the parent rock, presenting the hardening process by which the percolation of water highly charged with carbonate of lime had for the most part converted them into a compact limestone. The above passed into a stratum, 3 ft. in thickness, of red loam highly impregnated with iron, and containing pebbles with a few larger sandstone blocks; the latter form another layer several feet in thickness on the top of the last. These blocks are far more rounded and waterworn than the lowermost, with deep grooves and hollows scooped out on their surfaces,—the largest attaining a girth of from ten to fifteen feet, and showing, as in the case of all the stones in the gap, the metamorphic process referred to, which proceeds from without inward, so that many present an outer ring of a pale green limestone, whilst the inner part retains the original soft porous texture of the rock. It was in this layer, situated from 22 to 25 feet from the surface, that the greatest amount of organic remains was discovered, more especially on the eastern side, where the blocks are not so numerous and the soil is more closely packed between them than on the west side, where the stones were more crowded, with little soil between them, and that of a finer consistence, as if it had been ground by attrition between the blocks. As before, another layer of pebbles and soil lay on the top of the last-mentioned stratum and to within about 4 feet of the surface, where the deep-red loam changed to a white calcareous drift, containing scattered fragments of sandstone, which showed some appearances of stratification. Thus the section displayed several distinct alternations of large blocks and layers of loam and pebbles, representing periods of violence and comparative quiescence such as might be expected from occasional violent floods and freshets succeeded by less powerful currents which only bore down the lighter detritus. This is well seen in the layers of red loam with waterworn pebbles interspersed throughout at various levels, as if they had slowly sunk in the soft mud at the bottom of a stream. The organic remains were discovered at all levels, excepting in the white upper drift, and showed undeniable traces of the forces which had acted so powerfully on the other contents. Among the large blocks of sandstone were found portions, and, in one or two instances, seemingly entire skeletons of elephants, together with numbers of the great dormouse, between the masses of rock, as if the Rodent had been drowned and had sunk into the hollows between the stones. Fragments of birds' bones of large dimensions, together with those of the great river-tortoise, a small lizard about the dimensions of the common chameleon, and frogs, were met with chiefly in the red loam and pebbly strata. Land shells in large numbers, principally belonging to *Helix* and *Clausilia*, were frequently found under the largest

blocks, or strewn along with the other animal remains. Several skulls of elephants with the teeth *in situ* were found impacted between blocks as if they had been retained by means of rock which had fallen on them with considerable force, as was further testified by the underlying mass having been cracked by the violent impact of the one above it. In one situation the right lower ramus of an elephant, almost entire, with the loss only of its condyle, was found jammed between two large blocks, one of which had struck the jaw at the commencement of the diasteme on the inner side, and bent the anterior portion nearly at right angles. Nevertheless tusks, almost entire, were often met with even among the smaller stones. The bones and the teeth were for the most part covered by calcareous incrustation, taking the shapes of dendrites; and frequently the larger bones, skulls, &c. were encased in layers of stalagmitic red soil, as if the hardening of the matrix had been the result of decomposition of the soft parts after deposition in the gap. The extent of my explorations in Benghira gap did not exceed a section of about 8 feet in thickness; nevertheless there turned up, more especially among the large blocks, teeth of upwards of twenty-four individual elephants, of all ages, from the unworn crown of the calf to the last true molar of the aged. Several detached bones displayed traces of former exposure to the atmosphere, by the presence of cracks and honeycombed perforations. The appearance presented by this remarkable collection of organic remains seems to me to indicate clearly that the gap had at one time formed the bed of a stream subject to occasional violent floods, which bore down whatever animal remains came within its reach. The direction of this ancient torrent-bed is not now traceable beyond a few hundred feet south-westward, owing to the changes of level and the advancement of the sea on the coast-line. At all events the evidence is strong that the aqueous agencies which conveyed the contents of Benghira gap into their present situation must have been of no common order or intensity, whilst the blocks were not conveyed from any great distance, at a period, too, when the denudation of the district was about the same as at present.

My recent explorations in the Maltese post-tertiary deposits clearly demonstrate that, besides the pigmy fossil elephant, so named by the late Dr. Falconer from remains collected by Captain Spratt in the cave of Zebbug, I have also found undoubted remains of an elephant which attained the dimensions of a small-sized Asiatic or African species. The data from which I have deduced this statement have been fully recorded in papers sent to Professor Busk, where the dental characters of upwards of 120 individual elephants, besides the bones of the trunk and extremities, are set down with studied care and accuracy. I have therefore been brought to the conclusion that all the elephantine remains found by me in the Maltese alluvial deposits belong to one species. For example, the largest last true molar found by me gave a maximum length of 8·4 inches, and breadth of 2·3 inches, which is about equal to the dimensions of intermediate size between the first and second true molars of the Asiatic elephant. Again, of four first milk-teeth, only one of which showed well-marked signs of wear, the maximum length did not exceed ·55 inch, whilst that of the Asiatic is usually between ·6 and ·7 inch. All the tusks of the Maltese elephant had perfectly straight tips, and curved gently, as in the recent species. The largest yet discovered was found in Mnaidra Gap. It embraced a portion of the pulp-cavity, and 4 feet 2 inches of the body, and had a maximum girth of 15 inches, whilst at the distal fractured extremity it measured 13 inches, indicating that the species could not originally have been under 5 feet in length. On comparing certain vertebræ with those of the Indian elephant dissected by Blair, which was surmised to have been 26 to 28 years of age, and of middle stature, its height at the fore leg being at 8½ feet, I find that the diameters of the bodies of two

vertebræ from Mnaidra Gap slightly exceed those of the above. Allowing, therefore, for discrepancies as to size of the tusks, it is apparent that the owners of the above teeth and bones were not markedly diminutive species compared with any living or fossil elephant. The question, however, whether more than one species is represented by the remains in the Maltese deposits deserves the fullest attention, from the able remarks read by Professor Busk in a paper read before the Zoological Society of London with reference to the Zebbug cave-deposits, none of which I have had an opportunity of examining, with the exception of one molar; and that I have found equal to one of the intermediate teeth of the species here referred to.

The dentition of the Maltese fossil elephant as observed by me furnishes characters similar to the Loxodon group, whilst the crown-pattern resembles closely that of *Elephas antiquus*. The teeth, however, are relatively much smaller, and present a different ridge-formula, which, from the extensive and varied materials I have examined, appears to me, exclusive of talons, to stand as follows :—

| Milk-Molars. | True Molars. |
|---|---|
| 3 ÷ 7 ÷ 9 | 10 ÷ 11 ÷ 13 |
| 3 ÷ 7 ÷ 9 | 10 ÷ 11 ÷ 13–14 |

Remains of birds were very common in nearly all the localities, and embraced various species. *Raptores* of large dimensions were represented by foot- and wing-bones from Mnaidra Gap, where likewise, as before stated, water-birds, including gigantic *Grallæ* and *Anseres*, were plentiful. The presence of a very large river-tortoise was repeatedly confirmed by the discovery of heads of femurs and other portions of the skeleton; and besides the testacea enumerated in my last Report, I have found associated with the elephants' teeth and bones several specimens of a recent shell (*Helix spratti*) hitherto only met with in the Maltese Islands. From a digest of all the evidences deducible from the geological structure and fossil fauna enumerated in this and the previous Report, it may be inferred that the old Miocene formation, of which the Maltese group are composed, underwent subsequently extensive upheavals, and formed a considerable tract of land, tenanted by vast herds of *Hippopotami*, elephants, and other quadrupeds, together with birds and reptiles, almost specifically distinct from any species yet found elsewhere, and at a time when the land testacea were identical with those now inhabiting the islands,—that at a subsequent period the whole, or at least by far the greater portion of this area, was again submerged under the sea, and reelevated at a still later period, when, after various oscillations of level, the subterranean movements ceased, leaving the present insular fragments. The extent or direction of the ancient post-miocene land is at present a matter of mere speculation; but no doubt the obscurity hanging over the subject will in time be dissipated, when the shores and other islands of the great inland sea come to be carefully explored, especially Sicily, Candia, and the Eastern Archipelago, also the western portions of the Mediterranean, which promise rich stores, as has already been demonstrated by the wonderful discoveries made by Captain Brome in the caverns and fissures of Gibraltar.

I have in this and the previous Report attempted to lay before the Members of the Geological Section a cursory account of my researches in the caves, fissures, and alluvial deposits of the Maltese Islands; and now that I have finished my task, and been compelled by unavoidable circumstances to relinquish my labours, I cannot but here humbly express my high admiration of the encouragement I have received from the Members of the British Association. No doubt much yet remains to be done in the field of my late labours. I opine, however, that the data furnished by the splendid collection of ele-

phantine remains I have deposited with your Committee will satisfy both them and you that your generous aid has not been unrewarded.

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*Letter to the President*: Professor MATTEUCI *on Earth Currents.*

Florence, 1er Aout, 1866.

MON CHER AMI,—Je n'ai pas besoin de vous dire combien je regrette de ne pouvoir pas accepter votre cordiale invitation pour assister à la *British Association* de cette année ; j'ai été deux fois à cette réunion, à York et à Southampton, et j'en ai rapporté les impressions les plus douces et les plus chères de ma vie. L'Association Britannique est une des Institutions que je désire le plus de voir pénétrer et s'enraciner en Italie.

Je regrette d'autant plus de ne pouvoir assister à la réunion qui aura lieu en quelques jours à Nottingham, car j'aurais voulu attirer l'attention du Comité sur un sujet de recherche qui mérite toute l'attention et l'encouragement de l'Association. Je veux dire, l'étude des *courants électriques de la terre.* Depuis trois ans je m'occupe de ce sujet qui a interessé vivement en Angleterre beaucoup de savants et entre autres le célèbre Astronome de Greenwich. L'obscurité et l'incertitude qui règnent encore malgré ses travaux sur ce sujet dépendent principalement de deux causes ; c'est à dire, 1° de la manière imparfaite d'opérer qui introduisait des causes d'erreur dans les expériences : 2° de l'impossibilité où ont été jusqu'ici tous les Physiciens qui s'en sont occupés de varier convenablement les expériences. J'ai la certitude d'avoir absolument écarté la première difficulté et je crois de l'avoir prouvé assez dans deux communications que j'ai faites à l'Académie des Sciences de Paris en 1864 sur les courants électriques de la terre. Je vais bientôt communiquer à la même Académie des résultats nouveaux et encore plus concluants. Je défie les Physiciens qui se sont occupés jusqu'ici de ce sujet sans employer les électrodes de zinc amalgamé plongés dans la solution de sulfate de zinc neutre et saturée, je les défie d'affirmer que les déviations qu'ils observent sont dues à des courants électriques qui n'ont pas leur origine ou dans les électrodes, ou dans les couches terrestres immédiatement en contact de ces électrodes. Ils ont pu décrire de grandes variations des courants électriques dans leurs circuits et rattacher ces variations aux aurores boreales ou à des tempêtes magnétiques, mais ils n'ont pu rien assurer sur la direction et sur la force des courants terrestres. Ces défauts n'existent pas dans ma méthode d'opérer et, soit qu'on opère avec les lames de zinc préparées comme je l'ai dit et plongées dans les cylindres d'argile cuite qui plongent dans l'eau de deux puits placés à l'extrémité du circuit, soit qu'on tienne ces cylindres plongés dans une couche de gravier de la même qualité aux deux extrémités et qui forment une couche de à peu près 1 mètre cube, on est certain des deux manières, que les courants qu'on obtiendra dans ces circuits sont indépendants des causes d'erreur et qu'on peut les appeler courants naturels de la terre. C'est ainsi que je regarde comme parfaitement établi, qu'on a de ces courants toutes les fois que les extrémités du circuit plongent à des hauteurs différentes dans le sol et que ce courant est ascendant dans le fil métallique ; que la direction et l'intensité de ces courants sont indépendantes de la position, de la hauteur, et de la configuration de la partie métallique du circuit ; que lorsque les extrémités de cette ligne sont placées le long du méridien et plongent à une certaine distance entre elles, on a dans cette ligne une circulation d'électricité dont la direction est constante et qui est sujette à des variations régulières pendant le jour, tandis que cette régularité et cette constance cessent dans une ligne semblable équatoriale.

Mais cette partie de ma méthode ne suffit pas pour compléter ces recherches.

Il faut absolument abandonner les lignes télégraphiques et avoir des lignes expresses pour ces expériences comme celles sur lesquelles j'ai pu opérer au camp de St. Maurice, et avoir en même temps un certain nombre d'aides pour pouvoir exécuter une série d'expériences dans un temps qui ne doit jamais être trop long. Il faudrait donc pouvoir se procurer du fil de cuivre couvert de gutta-percha pour une longueur de 20 miles, qui au prix de £14 pour 1 mile anglais, coûterait £280. Evidemment, après un temps d'à peu près six mois d'expériences on peut calculer que ce prix ne serait pas diminué de plus d'un tiers. Ayant un terrain uniforme, horizontal, une plaine, il faudrait y construire deux lignes à angles droits de 10 miles l'une, c'est à dire, dans le méridien et dans l'équateur magnétique. Avant tout il faudrait s'assurer qu'il n'y a pas de différence dans les résultats en opérant sur une ligne suspendue sur des poteaux et sur une ligne parallèle et souterraine. L'observateur chargé de ces expériences devrait être placé au point où les deux lignes se croisent afin de pouvoir observer en même temps les deux galvanomètres ou boussoles-tangentes introduits dans les deux circuits. Il faudrait au moins deux observateurs pour continuer les observations pendant toutes les 24 heures. Aux quatre extrémités des deux lignes on devait avoir une garde chargée de maintenir les extrémités et les communications avec le sol en bon état, et ces gardes pourrait exécuter les modifications qui leur seraient indiquées d'avance. Il ne serait pas difficile d'obtenir avec une faible dépense ces *gardes* d'une administration télégraphique. En réussissant à s'assurer (comme j'ai raison de croire qu'il en est ainsi) que les effets sont les mêmes dans une ligne suspendue et dans une ligne souterraine, il y aurait de grands avantages à construire *souterraines* les deux lignes que nous avons dites.

Les recherches principales devraient être exécutées dans le but de connaître : 1° l'influence de la longueur des lignes ou couches terrestres sur les courants de la terre et cela en opérant en même temps sur trois lignes parallèles de 1, 5 et 10 *miles* : on pourrait après opérer sur ces trois lignes également parallèles mais placées normalement à la première position ; 2° Comparaison des effets des lignes suspendues et des lignes souterraines ; 3° Influence de la profondeur de la couche où plongent les extrémités. Pour cela on devrait avoir des lignes parallèles de la même longueur, dont les extrémités seraient placées à la surface, à 1 mètre à 2 mètres de profondeur, se mettant à l'abri de l'influence de l'humidité de la couche *immédiatement* en contact des électrodes. 4° Etude dans des conditions très-variées de l'influence sur les courants de la terre de la différence de niveau où plongent les deux extrémités. 5° Une assez longue série d'expériences pour pouvoir comparer les intensités et la direction de ces courants dans les deux lignes à angles droits et de longueur variable dans les différentes heures de la journée. 6° Etude comparative de ces phénomènes avec l'état électrique de l'atmosphère et le magnétisme terrestre. Après m'être occupé pendant si longtemps de ce sujet je n'ai aucune difficulté à affirmer qu'il y a la presque certitude de réussir à résoudre ces questions avec clarté. Je n'ai pas besoin de dire que les relations entre ces courants électriques de la terre et le magnétisme terrestre et l'électricité atmosphérique sont certainement un des problèmes les plus intéressants de la physique terrestre ! on doit ajouter que tous ces phénomènes sont intimement liés avec la nature et les lois de l'électricité, du magnétisme, de l'attraction universelle.

Je suis donc fondé à recommander l'étude de ce sujet aux encouragements de l'Association Britannique pour les Sciences, et par conséquent à son illustre Président de cette année dont je suis depuis bien des années et je serai pour toute la vie

Son très-affectionné

C. MATTEUCCI.

# NOTICES AND ABSTRACTS

OF

# MISCELLANEOUS COMMUNICATIONS TO THE SECTIONS.

## MATHEMATICS AND PHYSICS.

### MATHEMATICS.

*On Plane Stigmatics.* *By* ALEXANDER J. ELLIS, *F.R.S.*

THIS paper is a continuation of that read at the Bath Meeting (Report of the Brit. Assoc. 1864, Trans. of Sections, p. 2). By means of diagrams the meaning of the stigmatic line, stigmatic involution, stigmatic homography, and the stigmatic circle was illustrated, and these were shown to include the straight line and circle of Descartes, and the involution and homography of Chasles, as particular cases. The imaginary points of intersection of a stright line and circle, the imaginary double points, and imaginary double rays of an involution and homography, &c. were, for the first time, publicly exhibited on paper. And an attempt was thus made to show that the principle of stigmatics, as explained in the papers cited, affords a complete solution of the problem of the geometrical signification of imaginaries in the geometries of Descartes and Chasles, and establishes an unbroken agreement between ordinary algebra and plane geometry.

*On Practical Hypsometry.* *By* ALEXANDER J. ELLIS, *F.R.S.*

If the heights of the barometer be B, $b$ inches, the temperatures of the air A, $a$ degrees Fahr., and the temperatures of the mercury M, $m$ degrees Fahr. at the lower and upper stations respectively, then, for all British heights, the difference of the level of the two stations is

$$\left[\frac{(B-b)\times 52400}{B+b} - 2\tfrac{1}{2}\,.\,(M-m)\right]\times\frac{A+a+836}{900}$$

English feet to the nearest unit, with the same accuracy as by Laplace's complete formula. Beyond the British isles, small corrections for the alteration of gravity in latitude and on the vertical, have to be made, but when aneroid barometers are used, these corrections may be neglected, as being much inferior to the probable instrumental error. The heights must be taken in sections not exceeding 4000 feet each, both on account of the construction of the formula, and of the unknown law of variation of temperature. When the decrease of the temperature of the air does not vary nearly as the decrease of the height of the barometer, or the observations at both stations, when distant, are not simultaneous, or the two stations are not nearly north-east and south-west of each other, the results of barometric hypsometry must be received with great caution.

*Description of a New Proportion-Table, equivalent to a Sliding-rule* 13 *feet* 4 *inches long. By* J. D. EVERETT, *D.C.L., Assistant Professor of Mathematics in Glasgow University.*

The distinctive feature of the new arrangement consists in breaking up each of the two pieces which compose a sliding-rule into a number of equal parts, and arranging these consecutively in parallel columns, the columns in one of the two pieces being visible through openings cut between the columns of the other. The largeness of the scale is such that the space from 1 to 1·1 is divided into a hundred parts, the smallest of these being $\frac{1}{1000}$ of an inch long. The material employed is Bristol board, printed from copper plates, the dimensions of each board, exclusive of margin, being 16 by 8 inches.

Multiplication and division can be performed by this Table with the same accuracy as by four-figure logarithms, and with greater ease and expedition. Formulæ not adapted to logarithmic computation are thus rendered available, and with the aid of a small table of natural sines and tangents the calculations of nautical astronomy can be performed with great facility and with all needful accuracy.

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*On certain Errors in the received Equivalent of the Metre, &c. By* F. P. FELLOWS.

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*On* Tschirnhausen's *Method of Transformation of Algebraic Equations, and some of its Modern Extensions. By the* Rev. Prof. R. HARLEY, *F.R.S.*

It has long been known that any algebraic equation may be deprived of its second term by a *linear* transformation. Tschirnhausen introduced *quadratic*, and suggested higher transformations, and thus opened the way to great progress in the theory. He showed that by the solution of a linear equation and of a quadratic, any algebraic equation may be deprived of its second and third terms simultaneously. The complete quintic may in this way be reduced to a quadrinomial form. Erland Bring, Professor of History in the University of Lund, in a paper bearing date 14th December 1786, seems to have been the first to extend Tschirnhausen's method so as to reduce the quintic to a trinomial form by depriving it of its second, third, and fourth terms simultaneously. (See a paper by Prof. Harley, entitled "A Contribution to the History of the Problem of the Reduction of the General Equation of the Fifth Degree to a Trinomial Form," Quarterly Journal of Mathematics, vol. vi. pp. 38–47.) Bring's process has lately been simplified by Mr. Samuel Bills of Hawton, near Newark; and Prof. Harley explained to the Section how Mr. Bills's method might be extended so as to deprive the general equation of the $n$th degree of its second, third, and fourth terms by the solution of equations none of which rise higher than the third degree; and of its second, third, and fifth terms by the solution of equations none of which rise higher than the fourth degree. (See "Mathematics from the Educational Times," vol. i. pp. 8, 38–40, 57, 58.) Notice was taken of the labours of other investigators in the same field, particularly Mr. Jerrard, Sir W. R. Hamilton, Chief Justice Cockle (Queensland), Prof. Cayley, and Prof. Sylvester. The author concluded with some observations on the alleged solutions of the general quintic by the late Mr. Jerrard and Judge Hargreave.

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*On Differential Resolvents. By the* Rev. Professor R. HARLEY, *F.R.S.*

The author gave a short account of his researches on differential resolvents, particularly those connected with certain trinomial forms of algebraic equations. An abstract of these researches has recently been published by the London Mathematical Society. He also pointed out the coincidence of some of his own results with those obtained about the same time, quite independently, by Chief Justice Cockle, F.R.S., of Queensland.

The differential equation

$$br\left[x\frac{d}{dx}\right]^n u = a^n\left[\frac{n-r}{n}x\frac{d}{dx}+\frac{m}{n}-1\right]^{n-r}\left[\frac{r}{n}x\frac{d}{dx}-\frac{m}{n}-1\right]^r x^m u$$

(in which the ordinary factorial notation

$$[\phi]^\theta = \phi\,(\phi-1)\,(\phi-2)\ldots(\phi-\theta+1)$$

is adopted) is satisfied by the $m$th power of any root of the algebraic equation

$$y^n - axy^{n-r} + b = 0,$$

$u$ being considered as a function of $x$. This theorem implicitly involves the following, which was communicatd to the author by Chief Justice Cockle in a letter under date Brisbane, Queensland, Australia, October 17–18, 1865.

The differential equation for

$$y^n - xy^r - 1 = 0 \quad \ldots\ldots\ldots\ldots\ldots \quad (1)$$

is

$$\left[x\frac{d}{dx}\right]^n u = \left[\frac{r}{n}\,x\frac{d}{dx} + \frac{m}{n} - 1\right]^r \left[\frac{m-(n-r)x\frac{d}{dx}}{n} + n - r\right]^{n-r} x^n u, \quad \ldots \quad (2)$$

where $u = y^m$.

On this result Chief Justice Cockle, in the same letter, remarks, "The conditions under which (2) is immediately depressible by one or two orders are, that one or both of the relations

$$\frac{-m+\rho n}{r} = \alpha, \quad \frac{m+\sigma n}{n-r} = \beta \quad \ldots\ldots\ldots \quad (3, 4)$$

should be satisfied; $\alpha$ and $\beta$ being integers comprised between the limits 0 and $n-1$ both inclusive (zero I treat as an integer), and $\rho$ being an integer comprised between 1 and $r$ both inclusive, and $\sigma$ being an integer comprised between 1 and $n-r$ both inclusive. If both conditions are satisfied, but $\alpha = \beta$ then (2) is immediately depressible by one order. If (only) one condition be satisfied, the same thing holds. If both be satisfied, and $\alpha - \beta$ does not vanish, (2) is depressible by two orders."

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## *Remarks on* Boole's *Mathematical Analysis of Logic.* *By the* Rev. Prof. HARLEY, *F.R.S.*

The author's remarks were arranged under three heads. First, he gave some account of Boole's system as developed in his 'Mathematical Analysis of Logic,' and more elaborately in his great work on 'The Laws of Thought.' Next, he noticed some remarkable anticipations of Boole's views. And in the concluding portion of his paper he pointed out the direction in which he believed Boole's method might be usefuly extended.

1. He contended that in Boole's system the fundamental laws of thought are deduced, not, as has sometimes been represented, from the science of number, but from the nature of the subject itself. Those laws are indeed expressed by the aid of algebraical symbols, but the several forms of expression are determined on other grounds than those which fix the rules of arithmetic, or more generally of algebra; they are determined in fact by a consideration of those intellectual operations which are implied in the strict use of language as an instrument of reasoning. In algebra letters of the alphabet are used to represent numbers, and signs connecting those letters represent either the fundamental operations of addition, subtraction, &c., or, as in the case of the sign of equality, a relation among the numbers themselves. In Boole's calculus of logic literal symbols ($x$, $y$, &c.) represent things as subjects of the faculty of conception, and other symbols ($+$, $-$, &c.) are used to represent the operations of that faculty, the laws of the latter being the expressed laws of the operations signified. For instance, $x+y$ stands in this system for the aggregation of the classes or collections of things represented by $x$ and $y$, and $x-y$ for what remains when from the class or collection $x$ the class or collection $y$ is withdrawn; $x \times y$, or more simply $xy$, represents the whole of that class of things to which the names or qualities representeed by $x$ and $y$ are together applicable; and $x=y$ expresses the identity of the classes $x$ and $y$. The canonical forms of the Aristotelian syllogism are really symbolical; but the symbols are less perfect of their kind than those which are employed in this system. By adopting algebraical signs of operation, as well as literal symbols and the mathematical sign of equality, Boole was enabled to give a complete expression to the fundamental laws of reasoning, and to construct a logical method more self-consistent and comprehensive than any hitherto proposed. His calculus does not involve a reduction of the ideas of logic under the dominion of number; but it rests on a fact which its inventor

has rigorously established, viz., "that the ultimate laws of logic—those alone upon which it is possible to construct a science of logic—are mathematical in their form and expression, although not belonging to the mathematics of quantity." The term mathematics is here used in an enlarged sense, as denoting the science of the laws and combinations of symbols, and in this view there is nothing unphilosophical in regarding logic as a branch of mathematics, instead of regarding mathematics as a branch of logic. The symbols of common algebra are subject to three laws, viz.—

The law of commutation ..... $xy=yx$, ..... (1)

The law of convertibility of terms..... $x\pm y=\pm y+x$, ..... (2)

The law of distribution ..... $x(y\pm z)=xy\pm xz$..... (3)

These laws are fundamental; the science of algebra is built upon them. And they are axiomatic; each of them becomes evident in all its generality the moment we clearly apprehend a single instance. Now Boole has shown that the same laws govern the symbols of logic, and that therefore in the logical system the processes of algebra are all valid. But at the root of this system there is found to exist a law, derived from the nature of the conception of class, to which the symbols of common algebra are not in general subject. This law is named by Boole "the law of duality," and is expressed by the equations

$$x^2=x,\ y^2=y,\ \&c. \quad \ldots\ldots (4)$$

Now viewing the equation $x^2=x$ as algebraic, the only values which will satisfy it are 0 and 1. If therefore an algebra be constructed in which the symbols $x, y, z$, &c. admit indifferently of the values 0 and 1, and of these alone, it follows that "the laws, the axioms, and the processes of such an algebra are identical in their whole extent with the laws, the axioms, and the processes of an algebra of logic." Difference of interpretation alone divides them. Upon this principle Boole's logical method is founded. Propositions are represented as equations; these are dealt with as algebraic, the literal symbols involved being supposed susceptible only of the values 0 and 1; all the requisite processes of solution are performed; and finally the logical interpretation of the symbols is restored to them. Some illustrations were given of the application of the method. That method, to use the originator's own words, "has for its object the determination of any element in any proposition, however complex, as a logical function of the remaining elements. Instead of confining our attention to the 'subject' and the 'predicate,' regarded as simple terms, we can take any element or any combination of elements entering into either of them, make that element or that combination the 'subject' of a new proposition, and determine what its 'predicate' shall be, in accordance with the data afforded to us." In the same way any system of equations whatever, by which propositions or combinations of propositions can be represented, may be analyzed, and all the "conclusion" which those propositions involve be deduced from them.

2. Bacon, in his 'Novum Organum,' Liber Secundus Aphorismorum, A. XXVII., notices incidentally an analogy that exists between a well-known axiom in mathematics, and the fundamental canon of syllogism: he says, "Postulatum mathematicum, ut *quæ eidem tertio æqualia sunt etiam inter se sint æqualia*, conforme est cum fabrica syllogismi in logica, qui unit ea quæ conveniunt in medio." On this passage R. Leslie Ellis remarks, "The importance of the parallel here suggested was never understood until the present time, because the language of mathematics and of logic has hitherto not been such as to permit the relation between them to be recognized. Mr. Boole's 'Laws of Thought' contain the first development of ideas of which the germ is to be found in Bacon and Leibnitz; to the latter of whom the fundamental principle, that in logic $a^2=a$, was known (*vide* Leibnitz, Philos. Works, by Erdmann, p. 130). It is not too much to say that Mr. Boole's treatment of the subject is worthy of these great names. Other calculuses of inference (using the word in its widest sense), besides the mathematical and the logical, yet perhaps remain to be developed." (Bacon's Collected Works, vol. i. footnote on p. 281.) The reference to Leibnitz requires some correction, for on p. 130 of the edition cited, there is nothing whatever relating to the logical question. Probably the

passage intended is that which occurs on p. 103, where Leibnitz, in a paper entitled "Difficultates quædam logicæ," makes a near approach to the enunciation of the fundamental law of logic, although he does not, either in that paper or elsewhere, so far as is known, state the law explicitly. He does, however, observe that AB = BA, which is Boole's law of commutation; and further, that from the proposition, all A is B, we may infer that AB = A,—an inference which, applied to the identical proposition A is A, gives us Boole's law of duality, AA = A. One of Leibnitz's illustrations of this inference is very curious. "Quidam se appellabat GRÜNBERG, viridis mons. Sodalis ei dicit, sufficeret ut Te appellares Berg, mons. Quid ita? respondet prior, putasne omnes montes esse virides? Cui sodalis, ita, inquit, nunc certe, nam æstas erat. Ita illi naturalis sensus dictabat hæc duo coincidere, omnis mons est viridis et æquivalent viridis mons et mons." Boole did not become aware of these anticipations by Leibnitz until more than twelve months after the publication of his 'Laws of Thought,' when they were pointed out to him by R. Leslie Ellis. Ellis subsequently addressed to Boole some "Observations," which yet remain unpublished, on some of the elementary parts of his system. These "Observations," which are chiefly critical, throw much light on the writer's views respecting the possibility of developing other calculuses of inference besides the mathematical and the logical.

3. The space at our disposal for this abstract will not permit us to print Ellis's paper here *in extenso*, but the following brief extract will give a tolerably clear idea of its general character.

"It appears to be assumed in Chap. III. Section 8 ['Laws of Thought'], that in deriving one conception from another the mind always moves, so to speak, along the line of predicamentation, always passes from the genus to the species. No doubt everything stands in relation to something else, as the species to the genus, and consequently the symbolical language proposed is in extent perfectly general, that is, it may be applied to all the objects in the universe. But I venture to doubt whether it can express explicitly all the relations between ideas which really exist, all the threads of connexion which lead the mind from one to the other. It seems to me that the mind passes from idea to idea in accordance with various principles of suggestion, and that in correspondence with the different classes of such principles of suggestion, we ought to recognize different branches of the general theory of inference. This leads me to a further doubt whether logic and the science of quantity can in any way be put in antithesis to one another. From the notion of an apple we may proceed to that of two apples, and so on in a process of aggregation, which is the foundation of the science of discrete quantity. Or again, from the notion of an apple we may proceed to that of a red apple, and this movement of the mind in *lineâ predicamentali* is the foundation of ordinary logic. But it is plain *à priori* that there are other principles of suggestion besides these two, and the following considerations lead me to think that there are other exercises of the reasoning faculty than those included in the two sciences here referred to. In the first place, certain inferences not included in the ordinary processes of conversion and syllogism were recognized as exceptional cases by the old logicians. Leibnitz has mentioned some with the remark that they do not depend on the dictum *de omni et nullo*, but on something of equivalent evidence. The only question is whether we should be right in considering these cases as exceptions, and if they are so, to what they owe their existence. One instance is the *inversio relationis*, e. g. Noah is Shem's father, therefore Shem is Noah's son. Here we pass from the idea of Shem to that of his father, and *vice versâ*. The movement of the mind is along a track distinct from that which we follow, either in algebra or what we commonly call logic. The perception of the truth of the inference depends on a recognition of the correlation of the two ideas, father and son."

The author gave his reasons for believing that, when the "exceptional cases" referred to in the above passage are fully investigated, and a calculus is devised for their symbolical solution, it will be found that the processes involved in such a calculus formally coincide with the processes commonly employed in the solution of *functional equations*. He also pointed out that it was in this direction probably that Boole's method would be found to admit of extension—an extension analogous to that which Boole himself effected for the theory of the solution of differential

equations by the invention of an algebra of non-commutative symbols. To take the simple instance given by Ellis.

Noah = the father of Shem ;
$\therefore$ A son of Noah = a son of the father of Shem = Shem.

The process is formally identical with the following :—

$$x = \phi y ;$$
$$\therefore \phi^{-1}x = \phi^{-1}\phi y = y.$$

Examples of inference lying beyond the domain of the old logic are deserving of much greater attention than they have hitherto received. Professor De Morgan seems to be the only writer who has treated of such examples with any degree of fulness and ability. (See papers on the Syllogism, and on the Logic of Relations, in the Cambridge Philosophical Transactions.)

*On Complexes of the Second Order* *By* Dr. Plücker, *F.R.S., of Bonn.*

Dr. Plücker showed a series of models executed with great accuracy by Mr. Epkens of Bonn, calculated to illustrate his theory of complexes of the second degree. Such complexes are determined analytically by equations of the second degree between the coordinates of right lines in space. In any plane whatever the lines of such a complex envelope a curve of the second class, and every point in space is the centre of a cone of the second order generated by lines of the complex. If a plane revolves round any line within it regarded as an axis, the variable conic therein generates a surface. The same surface is enveloped by a variable cone of the second order, the centre of which moves along the same axis. Surfaces of this description are of the fourth order and the fourth class. The axis is a double line of the surface. The four circumscribed cones whose centres are the four intersections of the double line with the surface, degenerate into systems of two planes, each of which touches the surface along a curve of the second order. In each of four planes passing through the double line, the conic degenerates into two points; these points (singular points of the surface) are the centres of cones formed by tangents to the surface. The poles of the double line, with regard to all conics in planes passing through it, are situated on a right line, through which pass the polar planes of the double line with regard to all circumscribed cones.

The surfaces even of the more general description are easily constructed; the models exhibited belong to the special case where the double line is at an infinite distance. In this case the surfaces are formed by curves of the second class in parallel planes, having their centres on a right line. The circumscribed cones become circumscribed cylinders.

*On the Hyperelliptic Functions,* Göpel *and* Weierstrass's *Systems.* *By* W. H. L. Russell, *A.B., F.R.S.*

The author of these papers gave an explanation of the methods discovered by Göpel and Rosenhain for the comparison of the hyperelliptic functions. After pointing out their enormous complication, he stated that a simpler method had been discovered by Dr. Weierstrass, which he illustrated by showing how Abel's theorem had been employed by that mathematician in deducing the periods of elliptic and hyperelliptic functions.

*On a Property of Surfaces of the Second Order.* *By* H. J. S. Smith, *F.R.S.*

*On the large Prime Number calculated by* Mr. Barratt Davis. *By* H. J. S. Smith, *F.R.S.*

*On a Nomenclature for Multiples and Submultiples to render absolute Standards convenient in practice, and on the fundamental Unit of Mass.* *By* G. J. Stoney.

*On the Partition of the Cube, and some of the Combinations of its parts.* *By* CHARLES M. WILLICH, *late Actuary and Secretary to the University Life Assurance Society.*

A cube may be divided into equal and uniform bodies in various ways.

1st. By lines from the centre to the eight angles of the cube, which will give six four-sided pyramids (B).

2nd. By lines from one of the upper angles of the cube drawn diagonally to the opposite angles, dividing the cube into three equal and uniform solids. Each of these solids being halved, forms a left- and right-handed solid. These six bodies produced, though equal in mass, differ so far in shape, as three may be termed left-handed and three right-handed, in the same way as the hands of the human body.

3rd. By lines drawn from the centre to four angles of the cube, and continued on each face, will produce four equal and similar bodies (G), each composed of two three-sided pyramids united at their base—the one having the same angle as the trihedral roof of the Bee's cell, viz. 109° 28′ 16″, the other 90°. These bodies rearranged produce the half of a *dodecahedron* with rhomboidal faces.

4th. Another division of the cube may be made producing the *tetrahedron* and *octahedron*, viz., by diagonal lines from two of the upper angles of the cube, continued on the other faces, will cut off four three-sided pyramids, leaving in the centre a *tetrahedron*. The four three-sided pyramids cut off may be so arranged as to produce the half of the true *octahedron*.

The four-sided pyramid obtained by the first mode of division being cut into two portions by a diagonal line will produce a body which I have assumed as a unit (A) for the construction of many geometrical and crystalline bodies. The models laid before the Association show some of the forms produced. The rhomboidal cube (J), and the rhomboidal dodecahedron (L) with pyramidal faces (containing in mass one-half of the cube from which it is derived), may be considered interesting; but the various crystalline figures which may be formed by a combination of my unit (A) I cannot even estimate—though probably all geometrical solids and even many, if not all, crystalline bodies may be included, if we use sections of bodies produced by a partition of the cube.

It may be observed that the pyramid (B), or one-sixth of the cube, which contains two units, may itself be divided into four bodies by sections parallel to the sides, each of which is one-third of a cube containing one-eighth of the mass of the cube from which it was derived; so that, in fact, we may go on dividing and reproducing bodies of a similar shape, and still retaining the same angles as in the portion from the original cube. How far this subdivision may be carried in nature, or how much further than our powers of vision will reach, I will not venture an opinion. We can imagine that the commencing atoms may be infinitely small when we remember the wonders revealed by the microscope.

I entertain a sanguine hope that, should the attention of philosophers be drawn to this subject, the further development may perhaps be the means of throwing some unexpected light as to the shape of an *atom*. I incline, however, to think that atoms may differ in shape in the three kingdoms of nature—mineral, vegetable, and animal.

As to the practical use in education, I am of opinion that the study of geometry would be simplified by the use of models showing the relative value as to the solidity of geometrical bodies, and thus convey knowledge to the youthful mind by means of the eye more readily than by any description, as when convinced by the sight the mind would understand with greater facility.

*List of models which accompanied the above paper.*

A. The *unit* or $\frac{1}{12}$ part of the cube having a side of 1 inch.

B. 1st union of two units, forming a low four-sided pyramid of which six make up a cube.

C. 2nd union of two units, forming a high four-sided pyramid of which six also equal cube.

D. 3rd union of two units, forming right-handed solid, being $\frac{1}{6}$ of cube.

E. 4th union of two units, forming left-handed solid, being $\frac{1}{6}$ of cube.

F. 5th union of two units, forming part of body G, which is the fourth part of cube.

G consists of 3 units, forms one-fourth of cube, and is the body obtained by the third mode of dividing the cube.

H. Cube composed of 4 of the above bodies, G.

I. Four of the same bodies (G) reversed and rearranged to produce the half of the rhomboidal dodecahedron. Another cube similarly divided and arranged completes the solid.

J. Six units or three of C so arranged as to produce the *rhomboidal cube*—the basis of the hexagonal system. Seven of these bodies build up the *bee's cell*.

K. The cube divided by cutting off four three-sided pyramids, leaving a *tetrahedron* in the centre. The four three-sided pyramids cut off may be so arranged as to produce the half of the true *octahedron*.

L. *Rhomboidal dodecahedron* with pyramids (C) on each of the twelve faces. This body contains forty-eight units (A).

M. The remainder of the large cube having a side of 2 inches, consists of forty-eight units (A) so arranged as to show how the *rhomboidal dodecahedron* (L) can be inserted in the vacant space.

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## ASTRONOMY.

### *Remarks on the Variable Star lately discovered in Corona Borealis.* *By* J. R. HIND, *F.R.S.*

Early in June last the author received a letter from Mr. W. Barker, of the Customs Department, London, Canada West, stating that the remarkable variable star in Corona Borealis, which was seen in Europe on May 13, had been discovered by him on the 4th of that month. He thus describes its variations:—"I first observed it on the 4th of May at 9 P.M., when it was somewhat brighter than Epsilon Coronæ; it rapidly increased until the 10th, when it was fully as bright as Alphacca (Alpha Coronæ); it was at its maximum. On the 14th it had decreased to the third magnitude, on the 18th to the fifth. On the 19th I could just discern it, and on the 20th I could see it no longer with unaided vision. On the 20th I observed it through my telescope (one of Cooke's 5 feet 4 inch object-glasses). With a power of 133, it showed a beautiful clear disk, and was exceedingly brilliant, and had a ruddy tinge. I still see it as a telescopic star; its light about equal to the companion of Polaris." As far as the author was at present informed, Mr. Barker did not make a public announcement of his discovery until the 16th of May, when he communicated a paragraph to the 'London Free Press,' and forwarded copies of the paper to various astronomers in this country. It runs thus:—"Astronomers will be interested to learn that a new star has made its appearance in the constellation of Corona Borealis. It is of the third magnitude, and is situated about one degree S.E. by E. of Epsilon Coronæ, and three degrees from Pi Ophiuchi, in a direct line between the two. It also forms the apex of an equilateral triangle with Beta and Zeta Herculis. Hour of observation, 9 P.M., 14th May, at London, C.W." It will be remarked that in this communication no reference is made to any observation of the star previous to the 14th of May, probably because Mr. Barker merely intended his notice to refer to its appearance at the date of his letter. But these observations are of historical and scientific value; and the author has not failed to press for any further particulars or corroborative facts which it may be in Mr. Barker's power to furnish. Several European astronomers, ignorant of Mr. Barker's observations, have conjectured that the star must have burst forth with astonishing suddenness. Mr. Schmidt, of Athens, a practised observer, thought it could not have been so bright as a star of the fifth magnitude on the 12th of May, early in the evening, or he must have perceived it; and M. Courbisse, at La Rochelle, was convinced it was invisible to the naked eye on the 11th; yet at this date it must have shown, according to Mr. Barker's observations, as a star of the second magnitude. This is by no means a solitary instance in proof of the little value which attaches in many cases of a similar kind to merely negative evidence. In his own astronomical practice the author had met with startling instances, and striking ones

may be found in the history of these phenomena of variable stars. Tycho Brahé thought the celebrated new star of 1572, which he detected on returning home from his laboratory, and which was then shining as a star of the first magnitude, could not have been visible an hour or so previously, and yet, keen observer as he was, he is well known to have been preceded by several days in the discovery of that wonderful object. Astronomers generally, however, may not be disposed to attach so little weight to negative evidence in a case of this kind, as from his own experience Mr. Hind was inclined to do, and it will be most desirable to possess every particular relating to Mr. Barker's observations between the 4th and 14th of May, which it may be in his power to furnish. Mr. Barker thinks he saw this star one or two years earlier, when the constellation was in the S.E., about 9 P.M., and Sir John Herschel announces his having recorded a star in this very position in one of his revisions of the heavens. The apparition of this star will be memorable as having afforded an opportunity of applying the spectrum-analysis to one of this class of objects. The valuable and highly interesting observations by Mr. W. Huggins and others are the results.

## LIGHT.

*Optics of Photography.—On a New Process for equalizing the Definition of all the Planes of a Solid Figure represented in a Photographic Picture. Means of producing Harmonious and Artistic Portraits.* *By* A. CLAUDET, *F.R.S.*

[This paper was published in the Philosophical Magazine for September 1866.]

*On a New Geometrical Theorem relative to the Theory of Reflexion and Refraction of Polarized Light (Isotropic Media).* *By* M. A. CORNU.

The direction of the luminous vibration relatively to the plane of polarization of a ray has not been yet stated in a way which is quite incontestable. Fresnel, in his admirable memoir 'On the Mechanical Theory of the Reflexion and Refraction of Polarized Light,' concludes that the vibration is perpendicular to the plane of polarization. M'Cullagh and Neumann have arrived at the same formulæ, but by supposing, on the contrary, that the vibration is within the plane of polarization. It seems that no middle term can exist between these two theories, and that the three rays have necessarily their vibration in the identical position compared with their respective plane of polarization. However, there is a third method, or, in other words, a third theory, extremely simple,—the author would not say extremely plausible,—which will lead us to the opinion of Fresnel respecting the refracted ray, and to the opinion of M'Cullagh respecting both the others. The only principle to be admitted, besides the exact transversality of the vibrations, is the following—the refracted vibration is perpendicular to the incident and reflected vibrations. We have, indeed, no theoretical ground for admitting, *à priori*, this principle; but if the consequence of it agree with the results of the other theories, it deserves to attract the attention of theorists in optics, and, in fact, it will constitute a new theorem. With the help of this principle, it is easy to determine the position of the reflected and refracted vibrations, if the position of the incident vibration is given. The resulting formula is

$$\frac{\tan \alpha}{\cos (i-r)} = \frac{\tan \beta}{\cos (i+r)} = \cot \gamma,$$

in which $\alpha$, $\beta$, $\gamma$ are the angles of the incident, reflected, and refracted vibrations with the plane of incidence, $i$ and $r$ the angles of incidence and refraction. Seeing that the vibrations are besides transversal, the above formula determines them completely. But if this theory is exact, that formula is nothing else than the analytical translation of the law of the rotation of the planes of polarization of the three rays—a law first stated by Fresnel, and which, according to the same rotations, may be written

$$\frac{\cot \alpha}{\cos (i-r)} = \frac{\cot \beta}{\cos (i+r)} = \cot \gamma,$$

$\alpha$, $\beta$, $\gamma$ being the angle of the vibration with the plane of incidence. M'Cullagh

arrives, on the contrary, at the expression

$$\frac{\tan\alpha}{\cos(i-r)} = \frac{\tan\beta}{\cos(i+r)} = \cot\gamma.$$

It is obvious that our formula agrees with the formula of Fresnel for the refracted ray, and with the formula of McCullagh according to the incident and reflected rays. It is easy to conclude, from this theory, that under the normal incidence the luminous vibration rotates a right angle when the ray penetrates into the second medium. It would be interesting to look for a direct verification of that conclusion; but it seems difficult to realize an experiment in which the surfaces limiting the medium do not produce an even number of those rotations, so that the vibration does not come again to its first direction. The author could have stated this property of polarized light under a more modest form, that is to say, as a simple corollary of known theorems; but he fancied that it was more useful, in the actual state of optics, to state it as a new theory, in order to show, first, that the geometrical simplicity of the principles does not constitute the most plausible theories: thus it is prudent to conclude that the greater geometrical simplicity of the McCullagh theory is no sufficient ground for rejecting the theory of Fresnel, though more complicated. Besides, the proposal of a new principle, very little obvious, *à priori*, is a good occasion to remember the feeble degree of evidence for the principles used in the other theories. After a further examination, it will appear that it is neither more nor less difficult to admit that the refracted vibration is perpendicular to both the others, than to admit, for the density of the luminous ether, the theories of Fresnel or McCullagh.

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*On Dispersion-equivalents.* *By* Dr. J. H. Gladstone *and* Rev. T. P. Dale.

The refractive index of a substance minus unity, divided by its density, is termed its "specific refractive energy," and the product of this and its atomic weight, or $P\frac{\mu-1}{d}$, is termed its "refraction-equivalent." But the refractive index $\mu$ differs according to the part of the spectrum observed. As the fixed lines A and H are the extremes in the two directions which can be measured under ordinary circumstances, $\mu_H - \mu_A$ has been taken as the measure of dispersion; and in a previous paper the authors had called $\frac{\mu_H-\mu}{d}$ the "specific dispersion." Hence the difference between $P\frac{\mu_A-1}{d}$ and $P\frac{\mu^H-1}{d}$, or more simply $P\frac{\mu_H-\mu_A}{d}$, may be termed the "Dispersion-equivalent;" and as $P\frac{\mu-1}{d}$ is little affected by the manner in which the substance is combined with other bodies, it becomes a matter of interest to inquire whether the same holds true with respect to $P\frac{\mu_H-\mu_A}{d}$.

It has been abundantly shown that the refraction-equivalent of the combination $CH_2$ is 7·6: its dispersion-equivalent, as determined from eight different substances or series belonging to the great vinic group of organic compounds, varies only within the limits of 0·32 and 0·38, the mean being 0·35. But when we turn to the benzole group its dispersion-equivalent is found to be 0·62, and in the pyridine group 0·58.

The determinations of the dispersion-equivalents of chlorine, bromine, and iodine also differ, when they are made from different groups.

Phosphorus is an extremely dispersive body, and when in a liquid condition gives for $P\frac{\mu_H-\mu_A}{d}$ the high number 2·9, though the value of P for this element is low.

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*Spectroscope de poche.* *Par* Dr. J. Janssen.

Cet instrument est à vision directe, et forme une très-petite lunette. Le redresse-

ment du faisceau est obtenu au moyen d'un prisme composé construit sur le principe de celui de M. Amici ; ce prisme composé est formé de deux prismes de flint à 90°, faisant corps avec trois prismes de crown. Le prisme de crown central est à 90°. Les deux prismes de crown terminaux, sont taillés sous des angles convenables pour procurer le redressement du faisceau. Ce système jouit d'un pouvoir dispersif considérable, et conserve au faisceau presque tout son pouvoir lumineux à cause de la faible valeur des réflexions intérieures. La Lunette qui sert à explorer le spectre porte deux objectifs placés à faible distance l'un de l'autre. Cette disposition qui augmente beaucoup le champ de la lunette, permet d'embrasser le spectre d'un coup d'œil. Enfin une échelle gravée sur verre permet de mesurer la position des raies dans les spectres qu'on étudie.

J'ai fait cet instrument en 1862. Il a été présenté à l'Académie des Sciences de Paris (Comptes Rendus, Oct. 1862) et à l'Académie de Rome (Déc. 1862). Il est employé par le P. Secchi dans ses recherches de physique céleste. M. Hofmann, de Paris, l'a construit sur mes indications.

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## *Sur le Spectre Atmosphérique Terrestre et celui de la vapeur d'eau.*

*Par* Dr. J. Janssen.

J'ai l'honneur de faire part à la section de la découverte d'une propriété optique nouvelle de la vapeur d'eau. Cette propriété consiste en ce que la vapeur d'eau agit spécifiquement sur la lumière de manière à produire un spectre d'absorption caractéristique. Ce spectre permettra de constater la présence de la vapeur d'eau, et, par suite, de l'eau, soit dans les hautes régions de l'atmosphère terrestre, soit dans les atmosphères planétaires, et d'une manière générale dans les corps célestes.

En continuant les beaux travaux de MM. Brewster et Gladstone sur le spectre solaire, j'ai été amené à constater cette action de la vapeur d'eau par une longue suite d'observations sur la lumière solaire faites en diverses saisons de l'année. Pour des hauteurs égales du soleil, les raies telluriques du spectre solaire se montraient d'autant plus foncées que le point de rosée était plus élevé. (Voir les Comptes Rendus de l'Académie des Sciences de Paris ; 13 à 27 Juillet, 1863 ; 27 Juillet, 1864 ; 30 Janvier, 1867 *.)

*Spectre de la vapeur d'eau.*—Une expérience directe qui démontre définitivement cette propriété vient d'être faite à Paris dans l'usine de la Compagnie du Gaz. Un tube de fer de 37 mètres, fermé aux extrémités par deux glaces, a été rempli de vapeur à diverses pressions. Le tube de fer était placé dans une enveloppe de bois rempli de sciure de bois pour empêcher les déperdition de la chaleur. La lumière était donnée par une rampe de 16 becs de gaz. On sait que cette lumière donne un spectre continu et sans raies ; or, quand la lumière eut traversé le tube plein de vapeur à 7 atmosphères, elle donna un spectre sillonné de raies et bandes obscures correspondant aux raies et bandes atmosphériques terrestres ou telluriques du spectre solaire. (Ce sont les bandes découvertes par l'illustre Sir David Brewster quand le soleil est à l'horizon.) L'expérience a été répétée dans des circonstances diverses. On a examiné les effets de la longueur du tube et ceux de la pression. Les raies se développent à mesure que la longueur augmente ou que la pression s'élève ; elles s'affaiblissent dans les circonstances opposées. Quand le tube est vide de vapeur ou qu'il en contient fort peu, on ne voit aucune raie. Le resultat est donc parfaitement constaté. J'ai interrompu les expériences pour venir en faire part au Congrès, mais je compte en poursuivre les conséquences.

En attendant je puis déja conclure :

1. Que les raies du spectre solaire dans les régions rouge, orangée, jaune, sont presque toutes dues à la vapeur d'eau de notre atmosphère.
2. Qu'il n'y a pas de vapeur d'eau autour de la photosphère solaire.
3. Que la découverte du spectre de la vapeur d'eau vient confirmer les résultats obtenus par M. Tyndall, touchant l'action absorbante de cette vapeur sur la chaleur rayonnante.

* M. Cooke, en Amérique, vient d'annoncer des résultats semblables ; je suis persuadé qu'il n'avait pas connaissance de ces publications où j'ai formulé les conclusions de son travail dix-huit mois avant lui.

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*On a Fluid possessing Opposite Rotatory Powers for Rays at opposite ends of the Spectrum.* *By* Professor JOHN H. JELLETT.

The existence of this fluid was discovered in conducting a series of experiments with a new saccharometer which the author had formerly described to the Royal Irish Academy *, and which he now exhibited to the Section. In making use of this instrument, it became necessary to compare the rotatory powers of the two well-known species of oil of turpentine, namely:—1. The American oil of turpentine, which is obtained from the *Pinus australis* of North Carolina; and 2. the French oil of turpentine obtained from the *Pinus maritima* of Bordeaux. As these fluids, which are opposite in their rotatory powers, are chemically identical, and very slightly different in their refractive and dispersive powers, it was natural to expect that no difficulty would be found in determining the relative lengths of two columns of these fluids respectively, which should perfectly *compensate* each other. Two columns of fluid are said to compensate each other when a ray of polarized light, transmitted successively through these columns, emerges from the second column in the same state in which it entered the first. The actual result, however, was wholly different from this anticipation. When the relative lengths were so determined that the intensity of the light transmitted respectively by the two parts of the analyzer † was the same, the colours of these two spectra were wholly different. In reasoning on the difference of colour, the author was enabled to perceive that the American oil of turpentine was much more highly *dispersive* of the planes of polarization of the elementary rays than the French oil. It is plain, therefore, that if the lengths of the columns be so proportioned that the rotation may be the same for the mean ray, the more dispersive (in the sense just defined) fluid will turn the plane of polarization of the red ray through a less angle, and that of the violet ray through a greater angle than the less dispersive fluid. Hence, remembering that French oil of turpentine is left-handed, and American oil of turpentine right-handed, it is plain that if a red ray be transmitted through two columns, whose lengths are so proportioned, the total effect will be left-handed rotation; whereas, if a violet or a blue ray be so transmitted, the effect will be right-handed rotation. As these fluids, being identical in composition, could scarcely act chemically on each other, the same effects might be expected from a single fluid produced by mixing these two columns.

This the author found to be, in fact, the case. The rotating fluid was formed by mixing the two oils in the following proportion ‡:—

| | |
|---|---|
| American oil of turpentine | 67 |
| French oil of turpentine | 33 |

When a column of this fluid, whose length was 4 inches, was traversed by a solar ray which had been previously transmitted through plates of red and blue glass, the rotation produced in the plane of polarization of this, which is the extreme red ray, was found to be $-1° 35'$.

Again, when the same column was traversed by a ray which had been previously transmitted through a solution of ammoniacal sulphate of copper, the rotation was found to be $+2°$.

This phenomenon is best shown with solar light, but it may be shown, though with less distinctness, with the electric or oxy-calcium lights.

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*On Comets, and especially on the Comet of* 1811. *By* CORNELIUS VARLEY.

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## HEAT.

*Determination of the Mechanical Equivalent of the Thermal Unit by Experiments on the Heat evolved by Electric Currents* §. *By* J. P. JOULE, *F.R.S.*

* Proceedings, vol. vii. p. 279. † Ibid. p. 349.

‡ The proportion of oils, given above, must be understood to refer only to the particular specimens of the oils which were used in making these experiments. The rotatory power of commercial oil of turpentine, more especially that of the American oil, is very variable.

§ Printed *in extenso* in the Reports.

## ELECTRICITY.

### *On the Electrical and Mechanical Properties of* Hooper's *India-rubber Insulated Wire. By* W. HOOPER.

The author at a previous Meeting described the method by which he secures the durability of india-rubber. Diagrams representing the effects of pressure and immersion were shown, from which it was seen that pressure improves the insulation of his wire in the same way as is observed with gutta percha. The result of carefully-conducted experiments, extending over three years, proves that the absorption of water is so small that the most refined electrical tests failed to discover it.

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### *On the Depolarization of Iron Ships, to prevent the Deviation of the Compass. By* E. HOPKINS, *C.E.*

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### *Extract of a Letter from* Senhor CAPELLO, *of the Observatory, Lisbon, on Magnetic Disturbance, to* BALFOUR STEWART, *of the Kew Observatory.*

The author sent three Tables representing graphically the most important results deduced from the curves of our magnetographs for the year 1864. He had followed the plan of General Sabine in separating the greatest disturbances of the three elements. Thus he had considered as a disturbance of the declination every ordinate which differed from the monthly mean by 2'·3 or upwards; while the separating value for the horizontal force was ·0011 of the whole horizontal force, and that for the vertical force ·00032 of the whole vertical force. The instruments were at work during the whole of the year 1864; and of the 8760 hourly observations of each instrument, the observers only failed in measuring 97 for the declination, 139 for the horizontal force, and 159 for the vertical-force instrument. The number of disturbances have been—

| | |
|---|---|
| For the declination ..... | 1043 |
| For the horizontal force ..... | 810 |
| For the vertical force..... | 982 |

From a diagram exhibited, giving the hourly variations yearly and half-yearly of the three elements, it was seen that the progress of the declination for each period is very regular. The mean daily range of declination during the six months from April to September, while the sun is north of the equator, is 9'·20; while during the six months from October to March, when the sun is south of the equator, this range is less, being barely 6'. For the dip, the corresponding curves are much disturbed from 6 P.M. to midnight, especially for the six months when the sun is north of the equator. The total force gives a well-pronounced minimum at 11 A.M. during the six summer months, and $11^h\ 30^m$ A.M. during the six winter months. The daily range is greatest for the six summer months, and least for the six winter months.

The diagram of disturbances gives for the declination a maximum of the westerly disturbances at about 8 A.M., and a minimum about 10 in the evening. On the other hand, the maximum of easterly disturbances is about 10 in the evening, and the minimum about 6 in the morning.

The curves for the horizontal-force disturbances are irregular. The maximum of disturbances tending to *increase* the horizontal force takes place about noon, while the minimum is about 1 A.M. But here one is much struck with the great disproportion between the disturbances tending to *increase* and those tending to *diminish* the horizontal force, the latter being both the most numerous and the greatest in amount. The maximum and minimum of these latter disturbances take place a little later than the maximum and minimum of the disturbances tending to increase the force.

With respect to the vertical force, the curve of disturbances tending to increase this element resembles to some extent the curve of easterly disturbances, or disturbances tending to diminish the westerly declination. In this same diagram *blue* and

*red* curves were made to represent the whole effects of the perturbations, or the quantities which it is necessary to apply to the line of no disturbance, reckoned a straight line, in order to reconstruct the curves with the perturbations.

Thus the effect of disturbances upon the declination is to cause the needle to deviate towards the west during the hours of the day, but towards the east during the hours of the night.

The effect of disturbances upon the vertical force is of a reverse kind, tending to diminish this element during the hours of the day, but to increase it during those of the night.

With regard to the horizontal force, it appears that the disturbances tend to diminish this element almost during the whole of the twenty-four hours.

A third diagram represented the mean hourly movements of the north pole of the freely suspended needle in a plane perpendicular to the direction of such a needle, both for the whole year, and also for the winter and summer seasons.

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*On certain Phenomena which presented themselves in Connexion with the Atlantic Cable.* *By* C. F. VARLEY.

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*On a New Method of Testing Electric Resistance.* *By* C. F. VARLEY.

In 1860, Prof. Thomson and Fleeming Jenkin, F.R.S., invented a method of obtaining exact subdivisions of the potential of a voltaic battery. The apparatus consisted of a number of equal resistance-coils, say 100. These were connected one with one pole of the battery, and the other with the other pole. To the junction of each coil a piece of metal is attached, and a spring attached to a brass slide travelling along a square rod of the same metal traverses these different pieces, and so makes contact with whichever is desired. If the two poles of an electrometer be attached, the one to one pole of the battery, and the other to the brass bar on which the slide travels, it will be found that at the one end we have the full potential power, and at the other end nothing at all, and halfway half the potential; this is too self-evident to require further explanation, and is explained in Thomson and Jenkin's patent, 1860. Prof. Thomson has recently succeeded in making reflecting electrometers of such sensibility that they will give 200 scale-divisions for a variation of potential equal to one cell of Daniell's battery. In testing the Atlantic Cable this electrometer was used in the following way at Valentia, to get the potential of the ship's magnetism. The one pole of the electrometer was connected with the cable, and the other one with the slide, and by running it up and down the exact potential of the cable was measured. There were in the main slide 100 coils of 1000 units each, and it became necessary to subdivide these again 100 times to get sufficient accuracy. Some difficulty presented itself in getting a method for subdividing these coils, and the author was fortunate enough to hit upon the following very simple method of effecting this purpose. The slide consists of two square brass bars, over each of which travels a piece of brass, to the bottom of which is attached a spring, pressing upon the studs connected with the resistance-coils. Instead of using 100 coils in the main slide, the author uses 101, and makes the two springs to embrace two coils. Thus, then, the two bars of the slide have invariably a resistance between them of 2000 ohmads. The two bars are connected with a second set of 100 coils, each coil having 20 units resistance, and the 100 coils making up precisely the same resistance as that of two of the coils in the main slide. These two circuits of 2000 units each reduce the resistance to one-half, or to 1000 units, so that the resistance of the 101 coils of 1000 each is reduced to that of 100 coils. By passing the traveller along the 20 unit coils in the second slide an exact subdivision of the potential between these points is obtained; and in this way the potential of the battery is accurately and quickly subdivided to 10,000 parts. By these means Prof. Thomson has been able to introduce a method of testing, on the Wheatstone balance system, so extremely simple that it should be made known as soon as possible. The battery is connected permanently to the main slide, so that a current is always passing through it. Its resistance, 100,000 ohmads, is such that no sensible elevation of temperature is produced. The current is also passed into the cable through a definite re-

sistance, R. At the junction between the end of the cable and the resistance R a key is attached, which is connected by either the reflecting electrometer or a reflecting galvanometer with the slides. That position is sought upon the slide which has precisely the same potential as that of the cable at the point where it joins the resistance R. If now the potential of the battery be represented by $p$, and the resistance of the junction of the cable with R be represented by $p^1$, and if the two portions of the coil necessary to balance this potential be $n$ and $m$, it will be evident, on the principle of the Wheatstone Balance, that $n : m ::$ R : cable $x$ (the cable resistance). Thus, then, the resistance R being known, $p$ and $p^1$ being known, and the resistance or position on the slide noted, the resistance of the cable is accurately obtained.

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## METEOROLOGY.

*On the Olimate of Aldershot Camp.* *By* Sergeant ARNOLD, *F.M.S.*

The military station of Aldershot is in the county of Hampshire, bordering on Surrey, and is situated on an elevated site, about 320 feet above the level of the sea. It is distant about 40 miles from London, and about 50 from Portsmouth and Southampton, being in lat. 51° 15′ 25″ N., long. 45° 30′ W. The extensive area of ground occupied by the North and South Camps was formerly a barren heath, the soil consisting mostly of sand and gravel, covered by about seven inches of peat. On the north and south the Camp is much exposed: on the east it is slightly sheltered by hills that run from the eastern boundary of the North Camp to the South. On the south-east is a range of hill, called the "Hogsback;" these are the highest in the neighbourhood, affording great protection to the cultivation of hops, which is carried on so successfully that their growth is rapidly extending. The north-west and west are bounded by land under cultivation. Small woods or copses are numerous in the locality, consisting principally of stunted fir-trees and brushwood. A small river named Blackwater is the only one in the vicinity.

Meteorological observations during the past eight years yield the following results:—The mean height of the barometer at 325 feet above the mean sea-level is 29·610 inches; this, however, is only an average of seven years, a standard instrument not having been used for the whole of 1858. The highest observed reading of the barometer was 30·452 inches on January 9th, 1859; the lowest, 28·269 inches on January 14, 1865 (these observations being reduced to 32° Fahrenheit). The adopted mean temperature of the air is as follows:—January, 38°·4; February, 39°; March, 42°·1; April, 48°·4; May, 53°·2; June, 58°·8; July, 59°·9; August, 59°·9; September, 56°·6; October, 51°·5; November, 41°·8; December, 40°·3. The mean for the past eight years is 49°·2. The mean of all highest readings is 57°·6, and the mean of all the lowest 41°·9; the mean daily range of temperature being 15°·8. The highest temperature was 93° on July 12, 1859, and the lowest 8° on December 29, 1860, so that the extreme range of temperature is 85°. The mean degree of humidity (saturation = 100) is as follows:—January, 89°; February, 82°; March, 84°; April, 76°; May, 78°; June, 78°; July, 78°; August, 78°; September, 85°; October, 86°; November, 90°; December, 89°. The yearly mean is 83°. The amount of cloud is estimated on the usual scale, 0 being a clear sky, and 10 an overcast sky. The mean amount is 6·1. The month in which the largest amount of cloud occurred was December (7·2), and the least (5·1) in September. The individual monthly averages show that the most cloud state (8·5) occurred in December 1865, and the least (3·2) in June 1859. Rain falls on an average of 143 days of the year. The greatest number of days was 183 in 1860, and the least 113 in 1864. The average yearly rainfall is 25·24 inches. This is less than at any other station in Hampshire. The greatest yearly total was 33·89 inches in 1860, the least 17·13 inches in 1858. The greatest monthly fall was (5·80) in October 1865, and the least (0·16 inch) in February 1858. Taking the average of eight years, the wettest month is October, the mean amount being 2·96 inches, and the driest February, being 1·23 inch. The mean monthly amount of ozone is 1·7; the largest quantity occurred in May, the mean of which is 2·2, and the least 1·1 in December. The yearly relative propor-

tions of winds are from the N. on 80·1 days, from the E. on 72·3 days, from the S. on 88·7 days, and from the W. on 123·7 days. The force of wind was estimated from 0 to 6; 0 being a calm and 6 a hurricane, the mean force being 0·6; but Robinson's anemometer is not stationary more than twice a year.

During a residence of nearly ten years in the camp the author has had the good fortune to observe that, in comparison with any other station, civil or military, its "bill of health" forms a striking contrast to their published statistics.

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*On the Method adopted at Utrecht in discussing Meteorological Observations.*
*By* Dr. Buys-Ballot.

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*On an Error in the usual method of obtaining Meteorological Statistics.*
*By* Francis Galton, *F.R.S., F.G.S.*

The meteorological statistics of the ocean have been hitherto obtained by extracting observations from the logs of different ships, and by sorting those that were made in different geographical divisions of the ocean into corresponding groups. The usual geographical divisions are bounded by each 5th degree of latitude and longitude, and they therefore are 300 miles in length, and have an average breadth of 150 miles. Each of the groups is treated as if it were composed of observations taken at irregular periods, by a single person stationed at a fixed observatory in the centre of the group, that is to say, the barometer, thermometer, and other elements are determined by computing the simple mean of all the recorded observations. The proportion of winds that blow from the different points of the compass is computed in a similar manner. Only one limitation is exacted in respect to the admission of an observation into a group. It is that it should not have been made at an interval of less than eight hours from any other observation by the same ship, already included in the same group. Were it not for this limitation, a zealous observer might contribute hourly, or yet more frequent observations, which, by their multitude, would prevent the scantier observations of other ships from exercising a just influence on the average. In an extreme case of this description, the weather met with by a single ship on one particular voyage might mainly govern the computed results.

In a recent report on the condition of the Meteorological Department of the Board of Trade by Mr. Farrer, Captain Evans, and himself, were pointed out many objections to the existing methods of computing ocean statistics. The object of the present paper is to draw attention to yet another objection, and to show that an additional limitation is required before an observation ought to be admitted into a group. The objection was, that the observations made by a sailing ship are more numerous in respect to antagonistic winds or calms than in respect to favourable weather. Therefore, as some parts of the ocean are mainly frequented by outward-bound and others by homeward-bound ships, the means of the recorded observations in those parts must differ materially from the true average weather. When favourable winds are blowing, a ship is rapidly wafted across the area of observation, and comparatively few observations are made within it. The wind may continue blowing, but the ship is unable to record its continuance after it has left the area in question. On the other hand, if an antagonistic wind blows, or if calms or light breezes prevail, then the ship is delayed within the area, and continues making observations during the whole, or nearly the whole period of their continuance. Taking one course with another, a ship sailing with a favourable wind crosses one of the usual five-degree divisions of the ocean in twenty-four hours, or, in other words, in three eight-hourly periods of observation. Therefore the observations made by a ship resemble observations made at a fixed observatory under the instructions that only three eight-hourly observations were to be taken during the continuance of winds, say, from the northerly quadrant, but that when the wind was in the southerly quadrant the observations were to be continued during the whole of its duration. No one would be inclined to accept the means of these observations as a just statement of the weather, yet this is precisely what is given by the method of compilation adopted by the Meteorolo-

gical Department. The weather under which a ship enters a division may be of any description whatever, except that of an absolute calm in a sea without a current, and therefore has no bearing on the present question. It must further be observed that the error he had pointed out not only affects the winds, but all the meteorological elements so far as they are correlated with the winds; the temperature and dampness are especially affected by it. The method he proposed by which this error might be obviated, was to impose a limitation to the observations in respect to interval in distance, in addition to the existing eight-hourly interval in respect to time. He proposed that observations should not be included in the groups, unless the places where they were made were at least as far asunder, measuring in the direction of the ship's general course (and not along her tacks) as she could traverse with a favourable wind in eight hours. Then on an average not more than three observations would be accepted from a single log-book in any 5-degree ocean square. He did not possess data to show how far the accuracy of the existing wind charts is impaired by the neglect of this cause of error. He presumed that it would only be in certain parts of the ocean that it would exercise considerable influence on the computed proportions of the winds, but that the ratio of the calms would be everywhere exaggerated. It was sufficient that he should point out the error as one to be guarded against for the future, for he trusted that the whole of the work in the Meteorological Office would be submitted to recomputation, and that an improved method of handling and grouping the observations would be adopted, in accordance with the recommendation of that Report to which he had already alluded.

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### *On the Conversion of Wind-charts into Passage-charts.*

*By* Francis Galton, *F.R.S.*

The most direct line between two points of the ocean is seldom the quickest route for sailing-vessels. A compromise has always to be made between directness of route on the one hand, and the best chance of propitious winds and currents on the other. Hence it is justly argued that an inquiry into the distribution of the winds over all parts of the ocean is of high national importance to a seafaring people like ourselves. A knowledge of the distribution of the winds would clearly enable a calculation to be made which would show the most suitable passage in any given case.

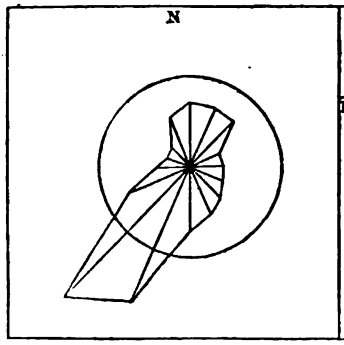
But as a matter of fact, no calculations have yet been made upon this basis; much less have charts been contrived to enable a navigator to estimate by simple measurements the probable duration of a proposed passage. The wind-charts compiled by the Meteorological Department of the Board of Trade are seldom used by navigators; for they do not afford the results that seamen principally require; they only give data from which those results might be calculated by some hitherto unexplained process, which, we can easily foresee, must be an exceedingly tedious one.

To convert wind-charts, or the tables of wind-direction from which the wind-charts have been compiled, into passage-charts, we must ascertain the distances that ships of different classes would attain in an hour, if they made the best of their way under the same wind towards different points of the compass. With a moderate wind, a merchantman of the class that usually navigates the Atlantic will, by beating to windward, make $2\frac{1}{3}$ miles an hour, right in the wind's eye. At two points off the wind it will make 3 miles; at four, 4 miles; at six, 7 miles; at eight, $8\frac{1}{2}$ miles: at ten, 9 miles; at twelve, $9\frac{1}{2}$ miles; at fourteen, $8\frac{3}{4}$ miles; and at sixteen, or with the wind right astern, it will make $7\frac{1}{2}$ miles. We must next turn to the wind-charts, or to the Tables from which they were compiled, to ascertain the proportion of the winds that blow from different points of the compass, in the region we are investigating. Thus in one particular case we find, out of one hundred observations, that six referred to N. winds, fourteen to N.N.E., seventeen to N.E., six to E.N.E., three to E., two to E.S.E., two to S.E., five to S.S.E., six to S., six to S.S.W., six to S.W., three to W.S.W., three to W., three to W.N.W., four to N.W., five to N.N.W., and nine calms. The force of the winds was not recorded in this instance; we must therefore, for want of better information, assume them to be moderate. We have now to calculate the progress that ships could make to-

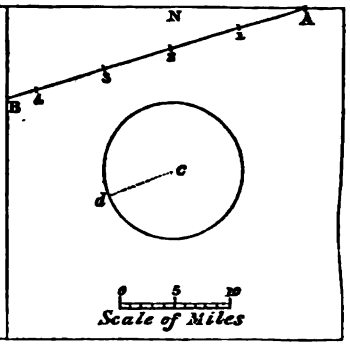
wards each point of the compass, under the several influences of each of these winds. In the example taken, the N. wind will be reckoned as lasting 6 per cent. of an hour, and therefore ships would be able to sail during its prevalence, ·014 mile to the N., ·018 to the N.N.E., and so on. The N.N.E. wind lasting 14 per cent. of an hour will enable ships to sail ·042 mile to the N., ·033 mile to N.N.E., and so on. The N.E., E.N.E., and all the other winds would have their influence similarly calculated. We thus obtain a Table of sixteen lines (not reckoning the line of zeros that correspond to "calms") and of sixteen columns, whose addition gives the total progress of one particular class of ships, in one hour, to all points of the compass, under the influence of the winds that blow in the ocean-district under consideration.

The bottom line of the Table gives the results that we seek. In the case we have taken, the diagram in the Wind-chart and that in the Passage-chart would be of the following shapes respectively:—

*Wind-chart Diagram.*




*Passage-chart Diagram, calculated from that of the Wind-chart.*




The proportion of winds from the neighbourhood of each of sixteen points of the compass is shown by the length of the corresponding lines drawn to the leeward of the centre. The radius of the circle represents the proportion of calms.

The force of the winds is not given in this diagram. It must therefore be reckoned as "moderate" throughout.

The probable length of an hour's sail in any direction from *c*, the centre of the diagram, is shown by the length of its radius in that direction. This gives a scale to be used throughout the ocean area to which the diagram refers.

*Example.*—Since A B is 4¼ times the length of the parallel radius *c d*, therefore the passage from A to B will occupy on an average 4¼ hours.

We should not be justified in usually adopting an "average force" for the winds, though, for simplicity of explanation, we selected the foregoing example, in which we were obliged to do so. If we confined our computation to the effect of simple averages, then an alternation of squalls and calms would be improperly reckoned as moderate weather. We must therefore group the winds, not necessarily to each degree of force, but, it may be, in two or perhaps three groups. The Tables would therefore consist not of sixteen lines, but of twice or thrice that number. For the rapid performance of these calculations we should tabulate the passages of various classes of ships to each of the sixteen points of the compass, under the influence of winds of, say, thirty different degrees of duration, and six of force, making a total of 180 lines for each class of ships. In each line the figures should be repeated, so as to sweep not only once but twice round the compass. If these are printed on separate slips of paper, the labour of copying them would be wholly avoided; for the same slips could be used over again. An *extract* from the foregoing Table will suffice for an example of what is meant; where, in order to save space, the figures that refer to the eight principal points of the compass are alone inserted.

| Hours of wind. | Direction of wind. | Corresponding passages in various directions (in nautical miles). | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N. | N.N.E. | N.E. | E.N.E. | E. | E.S.E. | S.E. | S.S.E. | S. | S.S.W. | S.W. | W.S.W. | W. | W.N.W. | N.W. | N.N.W. |
| 9 | Calms. | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 6 | N. | 14 | 18 | 24 | 42 | 51 | 54 | 57 | 52 | 45 | 52 | 57 | 54 | 51 | 42 | 24 | 18 |
| 14 | N.N.E. | 42 | 33 | 42 | 56 | 98 | 119 | 126 | 133 | 121 | 105 | 121 | 133 | 126 | 119 | 98 | 56 |
| 17 | N.E. | 68 | 51 | 40 | 51 | 68 | 119 | 144 | 153 | 161 | 149 | 127 | 149 | 161 | 153 | 144 | 119 |
| 6 | E.N.E. | 42 | 24 | 18 | 14 | 18 | 24 | 42 | 51 | 54 | 57 | 52 | 45 | 52 | 57 | 51 | 51 |
| 3 | E. | 25 | 21 | 12 | 9 | 7 | 9 | 12 | 21 | 25 | 27 | 28 | 26 | 22 | 26 | 28 | 27 |
| 2 | E.S.E. | 18 | 17 | 14 | 8 | 6 | 5 | 6 | 8 | 14 | 17 | 18 | 19 | 17 | 15 | 17 | 19 |
| 2 | S.E. | 19 | 18 | 17 | 14 | 8 | 6 | 5 | 6 | 8 | 14 | 17 | 18 | 19 | 17 | 15 | 17 |
| 5 | S.S.E. | 44 | 47 | 45 | 42 | 35 | 20 | 15 | 12 | 15 | 20 | 35 | 42 | 45 | 47 | 44 | 37 |
| 6 | S. | 45 | 52 | 57 | 54 | 51 | 42 | 24 | 18 | 14 | 18 | 24 | 42 | 51 | 54 | 57 | 52 |
| 6 | S.S.W. | 52 | 45 | 52 | 57 | 54 | 51 | 42 | 24 | 18 | 14 | 18 | 24 | 42 | 51 | 54 | 57 |
| 6 | S.W. | 57 | 52 | 45 | 52 | 57 | 54 | 51 | 42 | 24 | 18 | 14 | 18 | 24 | 42 | 51 | 54 |
| 3 | W.S.W. | 27 | 28 | 26 | 22 | 26 | 28 | 27 | 25 | 21 | 12 | 9 | 7 | 9 | 12 | 21 | 25 |
| 3 | W. | 25 | 27 | 28 | 26 | 22 | 26 | 28 | 27 | 25 | 21 | 12 | 9 | 7 | 9 | 12 | 21 |
| 3 | W.N.W. | 21 | 25 | 27 | 28 | 26 | 22 | 26 | 28 | 27 | 25 | 21 | 12 | 9 | 7 | 9 | 12 |
| 4 | N.W. | 16 | 28 | 34 | 36 | 38 | 35 | 30 | 35 | 38 | 36 | 34 | 28 | 16 | 2 | 9 | 12 |
| 5 | N.N.W. | 15 | 20 | 35 | 42 | 45 | 47 | 44 | 37 | 44 | 47 | 45 | 42 | 35 | 20 | 15 | 12 |
| Total hours 100 | All winds. | 530 | 506 | 516 | 553 | 610 | 661 | 679 | 672 | 654 | 632 | 632 | 668 | 686 | 683 | 652 | 589 |
| Or, in one hour. | All winds. | 5·3 | 5·1 | 5·2 | 5·5 | 6·1 | 6·6 | 6·8 | 6·7 | 6·5 | 6·3 | 6·3 | 6·7 | 6·9 | 6·8 | 6·5 | 5·9 |

| | | | N. | N.E. | E. | S.E. | S. | S.W. | W. | N.W. |
|---|---|---|---|---|---|---|---|---|---|---|
| N. | Hours 6 | Force mod. | 11 24 51 57 45 57 51 24 | 14 | 24 | 51 | 57 | 45 | 57 | 51 2 |
| N.E. | Hours 17 | Force mod. | 40 68 144 161 127 161 144 | 68 | 40 | 68 | 144 | 161 | 127 | 161 144 68 |
| E. ... | Hours 3 | Force mod. | 7 12 25 28 22 28 25 | 12 | 7 | 13 | 25 | 28 | 22 | 28 25 12 |
| S.E..... | Hours 2 | Force mod. | 5 8 17 19 15 19 | 17 | 8 | 5 | 8 | 17 | 19 | 15 19 17 8 |
| S..... | Hours 6 | Force mod. | 14 24 51 57 45 57 | 51 | 24 | 14 | 24 | 51 | 57 | 45 57 51 24 |
| S.W. ..... | Hours 6 | Force mod. | 14 24 51 57 45 57 | 51 | 24 | 14 | 24 | 51 | 57 | 45 57 51 24 |
| W..... | Hours 3 | Force mod. | 7 12 25 28 22 28 | 25 | 12 | 7 | 12 | 25 | 28 | 22 28 25 12 |
| N.W..... | Hours 4 | Force mod. | 9 16 34 38 30 38 | 34 | 16 | 9 | 16 | 34 | 38 | 30 38 34 16 |
| | | Total. | | | | | | | | |

If the slips were of sufficient length to include the data for every class of ship, a single operation would simultaneously build up Tables for all.

A navigator wishing to find the probable duration of his intended voyage, would refer to a chart on which the results of these calculations had been protracted in the form of diagrams. He must set his compasses to the radius of the diagram nearest to the commencement of his intended route, measuring it in a direction parallel to the route. He will thereby obtain a scale of probable distance for one hour's sail during that part of his voyage, and he will prick out his passage accordingly. When he has come within the range of another diagram he will set his compasses afresh. Continuing on this principle, he will dot out the probable duration of the whole of a proposed passage in the simplest possible manner. He will thus be able to select the quickest out of any number of routes that may be suggested to him, and to determine, on the most trustworthy of existing data, what is the best course to adopt in sailing from any one part of the ocean to another.

The method of altering a diagram so as to include the effect of a current, is too simple to require explanation.

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### *On the Heat attained by the Moon under Solar Radiation.*

*By* J. Park Harrison, *M.A.*

When the author brought forward the subject of lunar insolation a year ago, he showed by a simple diagram that the surplus, or accumulated heat in the moon, beyond what it radiates off to other matter into space, or owing to the long-continued action of the sun's rays upon her crust, would necessarily reach its maximum several days after the date of complete illumination. The mean duration of solar radiation for the two periods of first and third quarters is in fact in the proportion of 4·25 : 11·25; and, consequently, the days on which the moon's surface opposite to us is longest withdrawn from, or exposed to, the sun's heat (in other words, the days on which the moon completes her first and third quarters) would be not far removed from the days of her maximum and minimum temperature. He has since learnt that Herr Althaus, some few years back, approximately estimated a maximum temperature of 840° F. on the 22nd day of the lunation, seven days after the day of full moon. Althaus, it appears, measured the sun's radiation by the pyrheliometer, and then applying the results to the moon, deduced from the extent of her area the amount of heat intercepted; his measure of the moon's capacity for heat was that of quartz*. Assuming his deduction to be correct, the heat occasionally attained by the moon would approach very closely the temperature at which iron appears red in twilight, and it exceeds the fusing-points of tin and lead. Unfortunately the estimate cannot be compared with that made by Sir John Herschel which applies to the moon's heat at the period of complete illumination, at which time he states that it must be far in excess of boiling water. But

* Pogg. Ann. vol. xc. p. 551.

as the centre portion of the moon's crust at the last quarter has been exposed to some 180 additional hours of uninterrupted solar radiation, it is probable that the total heat attained must be very great indeed. Whatever temperature is acquired, the maximum will, it is believed, occur as stated, at or near last quarter.

As regards the date of the greatest cold in the moon, the German physicist already cited arrives at the conclusion that it occurs about half a day after first quarter; at the period, in fact, when, as was said before, the region of the moon opposite to us has been the longest time unexposed to the sun's rays. If a temperature of −92° Fahr. occurs at the time fixed by Althaus, it would suppose a fall of 940° Fahr. (522° Cent.) in about fifteen days. The author believes this interval would be required; for the conduction of heat through the moon's strata would be very gradual: and though it is true that bodies at very high temperatures cool, both in air and *in vacuo*, with great rapidity, yet it has been proved that the rate of cooling is greatest in air, by reason of its convection of heat. This is one of the laws laid down by Dulong and Petit, and admitted by those whose judgment in the matter is most to be relied on. The author has submitted the point to direct experiment in the receiver of the large air-pump at Kew, when the velocity of cooling, shown by a thermometer with a half-inch bulb coated with lampblack, for temperatures a little above the boiling-point, was found, for the first 100°, to be 25 per cent. greater in the glass filled with air, than in the exhausted receiver. Thus it would seem that the absence of an atmosphere would, in the case of the moon, favour an accumulation of heat, though in a different manner from that in which the presence of air and vapour affects the earth, where the slight heat stored up in its crust would be speedily lost if it were not for the counter-radiation from cloud and vapour.

As regards the theory that the solar rays would have no power to heat matter if surrounded by æther, there would seem no reason to believe that this is the case. It would be necessary that the observations which are supposed to point to that conclusion should be verified before the possibility of a result so unlooked for is admitted. Sir H. Davy found by experiment that absorption of heat from the coal-points of the electric light took place *in vacuo*; and the author's own experiment with the solar rays upon the blackened bulb of a mercurial thermometer, heated by means of a lens, in the 16-inch receiver already referred to, though undecisive as regards the relative speed of heating in air and *vacuo* with the sun as the source of heat, showed a gain of 160° Fahr. in two minutes (71° 11′ Cent.) in a vacuum of about one-eighth of an inch. Also in several experiments with thermometers with black and blackened glass bulbs enclosed in exhausted 2-inch globes, by Mr. Casella, and one with a lamp-blackened bulb in a globe filled with air made for the purpose, the thermometers in the exhausted globes (and more especially the one with the blackened bulb) were found to rise quicker and reach a higher maximum, in equal intervals of time, than the one in the globe filled with air. On a view of the whole case at the present time, there would seem to be reason to believe that the sun's rays must penetrate the moon's crust to a depth that would prevent the possibility of her acquired heat being easily or speedily dissipated, and consequently that the accumulation of heat under her vertical sun would reach a higher point than is generally supposed.

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*On the Diurnal Period of Temperature in relation to other Physical and Meteorological Phenomena.* *By* Prof. Hennessy, *F.R.S.*

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*On Meteoric Showers considered with reference to the Motion of the Solar System.* *By* Prof. Hennessy, *F.R.S.*

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*On a Table of Pairs of Stars for approximately finding the Meridian.* *By* W. J. Macquorn Rankine, *C.E., LL.D., F.R.SS. L. & E.*

The author stated that the object of the Table referred to was to give increased accuracy and utility to the well-known process of finding a meridian line approximately by choosing a pair of stars having nearly the same right ascension, and observing their direction at the instant of their being in the same vertical plane.

The Table contains a list of such pairs of stars, drawn up by Professor Grant, Glasgow Observatory; and with each pair there is given a *correction-factor*, which being multiplied by the secant of the latitude of the place of observation, gives the correction of the approximate meridian found by the process; that is to say, the true azimuth of a plane passing through the observer and the two stars at the instant when that plane is vertical. The following are the formulæ for the correction-factor C and its use:—

Let PA and PB be the polar distances of the two stars, D the difference of the right ascensions in seconds of angle; then

$$C = \frac{D}{\text{cotan } PA - \text{cotan } PB};$$

and if Z be the correction in azimuth in seconds of angle, and L the latitude of the place,

$$Z = C \,.\, \sec L.$$

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## Instruments.

### *On some Recent Improvements in Astronomical Telescopes with Silvered Glass Specula.* *By* John Browning, *F.R.A.S.*

During the last year I have devoted a large portion of time to an attempt to improve the construction of telescopes mounted with silvered glass specula. The methods usually adopted for mounting the speculum are, 1st, suspending it; 2ndly, supporting it upon an air-cushion, or a bed of felt; 3rdly, allowing it to rest on a number of balanced triangles.

All of these plans are open to the objection that the specula, when thus mounted, are very liable to get out of adjustment. The plan I have adopted consists in bringing the bottom of the speculum to a very accurate plane surface, and then placing it in an iron cell, the inner surface of the cell on which the speculum rests being also made an accurate plane. Mounted in this manner, the speculum can be removed from and replaced in the telescope without fear of deranging its adjustment.

The adjusting screws must be arranged so that they do not throw any strain on the iron cell, which would be liable to produce flexure in the speculum. Many specula have been mounted by this method, up to 10 inches diameter, with success.

It is known that the arm which carries the diagonal mirror in reflecting telescopes produces coarse rays on bright stars. Instead of the usual arm, I mount the diagonal mirror by means of three strips of chronometer spring strained tightly edgewise towards the speculum.

When observing stars with reflectors, the diffraction-rings surrounding them are greatly reduced by employing with all Huyghenian eyepieces a good Barlow lens.

Achromatic eyepieces (not the Kellner construction) give superior results to Huyghenian.

Tube-currents can be almost entirely avoided by making the body or tube of iron, which quickly equalizes the temperature of the air inside and outside the tube.

Should an observatory be built for a reflector, it should be made of sheet-iron as when constructed of this material the temperature inside and outside the building will be always nearly alike, and annoying air-currents, which would be generated in a building constructed of a non-conducting material, will not occur.

Reflecting telescopes require steadier stands than refractors, and the importance of securing this steadiness can scarcely be overrated.

With reflectors mounted as described, if the precautions which have been enumerated are adopted, the performance will almost rival that of good refractors and in dividing power excel them.

The Moon Committee of the British Association has recommended that observations upon the moon should be made with a power of 1000 diameters. Such a power can only be applied in telescopes of large aperture, which are very costly.

As the reflectors are only half the length of achromatic refractors of equal aperture, and their price is scarcely a quarter that of refractors of the same power, I believe, when their qualities are more generally known, they will be very extensively employed.

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*On a New Anemometer.* *By* L. CASELLA.

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*On a Variable Diaphragm for Telescopes and Photographic Lenses.* *By* A. CLAUDET, *F.R.S.*

This diaphragm is formed by a number of narrow strips of india-rubber, the two ends of which are respectively attached to two short tubes placed near the object-glass in the telescope, or in the middle of the photographic optical combination. One of the tubes can, to the extent of 180°, be made to revolve by the handle of an endless screw placed outside, and acting on a half-toothed circle fixed on the moveable tube, so that one end of each strip being attached to the immoveable tube, and the other end being carried round as much as half its circumference by the circle to which it is fixed; each strip, extending sufficiently by its elasticity during that motion, hides more and more the aperture of the tube, until it coincides entirely with its diameter. All the strips, acting simultaneously in the same manner, cross each other, and in doing so gradually reduce the aperture of the tube until it is shut entirely, when the strips overlapping one another form two cones with their apices turned towards each other.

The action of this diaphragm, being as rapid as may be needed, is very effective. It may be usefully employed in astronomical investigations, allowing the observer to alter gradually, or at once, the aperture of the lens, according to circumstances and different kinds of experiments.

This diaphragm is also very convenient in photographic operations, as it enables the artist, during the sitting, to increase or reduce rapidly the aperture of the lens according to sudden changes in the intensity of light. But it has another most important advantage in taking portraits, which consists in affording the means, first, to impart to the portrait a certain degree of softness resulting from the spherical aberration produced by the whole aperture, and immediately after, by gradually reducing the aperture until it is shut entirely, to communicate to the picture upon the slightly confused image another one sharply defined; the blending of the two effects producing an harmonious and artistic portrait, which could not be obtained separately, either by the whole aperture, or by the centre of the lens only.

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*On a Magnifying Stereoscope with a Single Lens.* *By* A. CLAUDET, *F.R.S.*

In the ordinary stereoscope each eye has its lens, but if a single lens be placed on any point where the optic axes may be directed and cross each other, such a lens is sufficient to enable both eyes at once, and each separately, to see through it, the slide placed behind containing the two pictures; each eye perceiving only the one, the perspective of which belongs to it. In looking with the two eyes the combined image appears in relief, and just as if it were situate on the lens itself, where, by the required convergence of the two optic axes, the two pictures seem really to coincide.

The pictures are mounted as usual on a slide, one near the other, but with the right perspective on the left, and the left perspective on the right, from whence through the single lens they can only, of course, reach their respective eyes. The slide must be placed at the distance behind the lens, which, corresponding with its focus, gives a distinct vision of the picture. The observer must place himself exactly before the lens, which is to be precisely in the middle of the space between the eyes and the pictures. Placing against the lens and in front of it a black card with a square opening, the picture appears on the plane of that opening, and as if it were seen on its usual square mounting.

For persons who (converging the optic eyes upon the lens) can keep them in that position while they look through it at the pictures behind (which, by a little practice, is easily acquired), the stereoscopic illusion is very complete, and the

effect exceedingly beautiful. The observer sees an enlarged square picture in full stereoscopic relief, without being conscious by what means it is produced, and without even noticing the apparatus which is employed; for the whole may be hidden by a screen, having in the middle of its surface a square opening upon which the eyes are directed.

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*Experiments off Ventnor with* Mr. Johnson's *Deep-sea Pressure-gauge.*
*By* J. Glaisher, *F.R.S., &c.*

In the year 1861 I brought under the notice of Section A a deep-sea thermometer and a deep-sea pressure-gauge, both instruments invented by Henry Johnson, Esq.

Experimental trials were made with these instruments by Sir F. Leopold McClintock during his sounding voyage in H.M.S. 'Bull-dog,' on the proposed route of the North Atlantic Telegraph in the year 1860.

In the experiments made with the deep-sea thermometer, the indications in various deep soundings, to the depth of 1400 fathoms, approximated to those of the best mercurial thermometers specially arranged for temperatures at great depths: my own observations upon one of these instruments daily recorded for six months, during which time it was suspended on a stand with other thermometers, at the Royal Observatory, Greenwich, also were in agreement. I have taken great interest in this thermometer, which is not liable to be affected by pressure of water; and which was contrived in consequence of some experiments made by me upon the temperature of the Thames water at Greenwich being frustrated by the pressure of water on the bulbs of the thermometers then used, at the depth of only 24 feet, when the pressure of water would be rather more than two-thirds of the weight of the atmosphere, as represented by the column of water of 32 to 34 feet in the water-barometer.

The deep-sea thermometer is composed of brass and steel, and the specific gravity of these metals being 8·39 and 7·81 respectively, they are not liable to compression by water, which acquires a specific gravity or density of 1·06 only, under a pressure of 1120 atmospheres, as determined by Mr. Perkins. This pressure is equal to a depth in round numbers of 5000 fathoms.

In the construction of the instrument advantage has been taken of the well-known difference in the ratios of expansion and contraction of the two metals by variation of heat to form compound bars consisting of a thin plate of each metal rivetted together. These bars assume a slight curve in one direction when heat has expanded the brass more than the steel, and a slight curve in the contrary direction when cold has contracted the brass more than the steel.

The indications of the instrument record the motions under changes of temperature of such compound bars, in which the proportion of brass, the more expansible metal, is about two thirds, and of steel one third.

To the lower end of a narrow plate of metal, about a foot long, are firmly fixed the ends of two such compound bars, the other ends being free to move to one side or the other, according to the action of temperature upon the more dilatable metal.

The free ends of these bars are connected by lateral arms to a needle moving on a pivot in its centre, at points equally distant from the centre, and the motion of the needle on its axis is regulated by the motion of the bars under the action of the temperature.

Three scales of temperature, ranging from 25° to 100°, and thus exceeding the range of the temperature of sea-water, are fixed upon the upper end of the plate, to the lower part of which the bars are attached.

Upon one of these scales the present temperature is shown by the needle or pointer (E), regulated by the motion of the bars. Two other needles moving upon the same pivot are useful as indexes, the needle (*g*) being pushed by a pin on the pointer (E) to the highest temperature attained, and the needle (F) to the lowest, where they are retained in position by stiff friction on their axis.

It will be observed that lateral concussion is avoided by the employment of two bars attached to the needle at points equally distant from its centre.

The experiments made by Sir F. Leopold M'Clintock with the deep-sea pressure-gauge showed that further improvements in the instrument were essential.

The pressure-gauge used by him in 1860 consisted of a brass cylinder, with a solid piston rod, in which the water was compressed in descending by the piston rod, forced inwards by the pressure of the denser external water until it became equally dense.

In filling this metallic cylinder, it was found that so many air-bubbles adhered to its internal surface as to interfere very materially with the results of experiment.

To obviate this difficulty, a cylindrical vessel of glass was adopted, with a graduated scale upon a long neck or stem, and closed with an elastic plug of caoutchouc, which when descending was forced inwards by external pressure, compressing the water in the pressure-gauge, and pushing along the graduated scale a spring index, which remained and marked the degree of compression, when the elastic plug was forced back again to the top of the scale by the expansion of the compressed water, as the pressure-gauge was raised again to the surface.

In this instrument the absence of air-bubbles was easily secured, but the difficulty of regulating with exactness the lubrication of this plug, and thus regulating the friction against the inner surface of the stem, rendered the results of experiments still somewhat uncertain.

The form of instrument now used combines the advantages of a transparent glass vessel with the absence of friction. It consists of a cylindrical glass vessel (A), having at one end a sphere (B) perforated with one or more small apertures, and covered with a close-fitting elastic diaphragm, and at the other end an oiled silk valve (D), resembling the valve of an air-pump, and admitting water into the cylinder under external pressure when descending, until the water in the pressure-gauge is of equal density with the external water. Upon a shoulder projecting near to the upper end of the cylinder a small glass vessel (H) is fixed, covering the sphere (B); and from it rises a small tube (I), graduated on such a scale that each part or degree is equal to $\frac{1}{2000}$ part of the volume of the water contained in the cylinder, and consequently one-tenth of a degree is equal to $\frac{1}{20000}$ part.

To protect the valve from grit, and also to prevent the admission of air into the cylinder, an elastic waterproof bag (E), with a perforated metal cover, is filled with water, and screwed on to the valve *under water* to exclude air; and the valve is then screwed into the end of the cylinder, which should be quite full of water, the superfluous water escaping through a slot in the valve-screw, so that air is excluded from the cylinder.

When the pressure-gauge is thus filled, and the case fastened, it is ready for sinking *valve downwards*, on a sounding line, into water of great depth.

When the pressure-gauge sent down is again raised into water of less density, the increased quantity of water forced into it by external pressure is retained by the valve in consequence of the elastic diaphragm covering the sphere yielding readily to its expansion, and being distended in proportion to the quantity of water forced in; and an equal quantity of water is expelled, through the open tube, from the small glass vessel (H) covering the sphere.

This displacement of water from the vessel (H) is the measure of the depth to which the pressure-gauge has been lowered, and the amount of it is ascertained readily by adjusting the water in the tube (I) to the degree 2000, and then turning the valve-screw (D) very slightly, to allow the excess of water to escape through the slot in the valve-screw, and the elastic diaphragm to sink again closely on the sphere, and then reading off on the scale-tube the height of the water remaining in it.

The moderate depths of water that can be attained on the coast of this country do not admit of any trial of the instrument as arranged for deep soundings.

However, some larger instruments were made, in order to test practically the principle on which the pressure-gauge has been constructed, at moderate depths; and the proportions of the cylinder and of the tube (I) were so arranged that one degree on the scale of the tube should be equal to $\frac{1}{20,000}$ part of the volume of the cylinder, and also should be one-eighth of an inch in length, so that variations were read without difficulty.

FIG. 1

FIG. 2

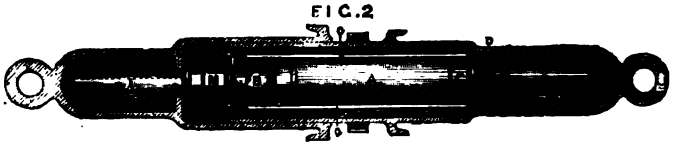


FIG. 3.

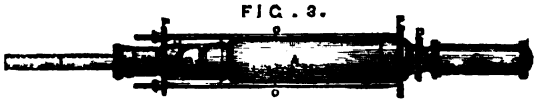
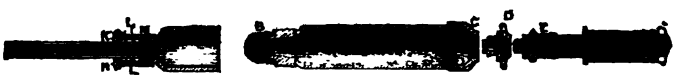


FIG. 4.



In July last Thomas Sopwith, Esq., F.R.S., Captain J. E. Davis, of the Hydrographic Department at the Admiralty, Mr. Johnson, my son and I, went to Ventnor in the Isle of Wight, off which place is a depth of water of 40 fathoms, which is a greater depth than can be conveniently obtained at any other place near the coast, and we succeeded in obtaining the following series of experiments on July the 23rd, 24th, 25th, 26th, and 31st:—

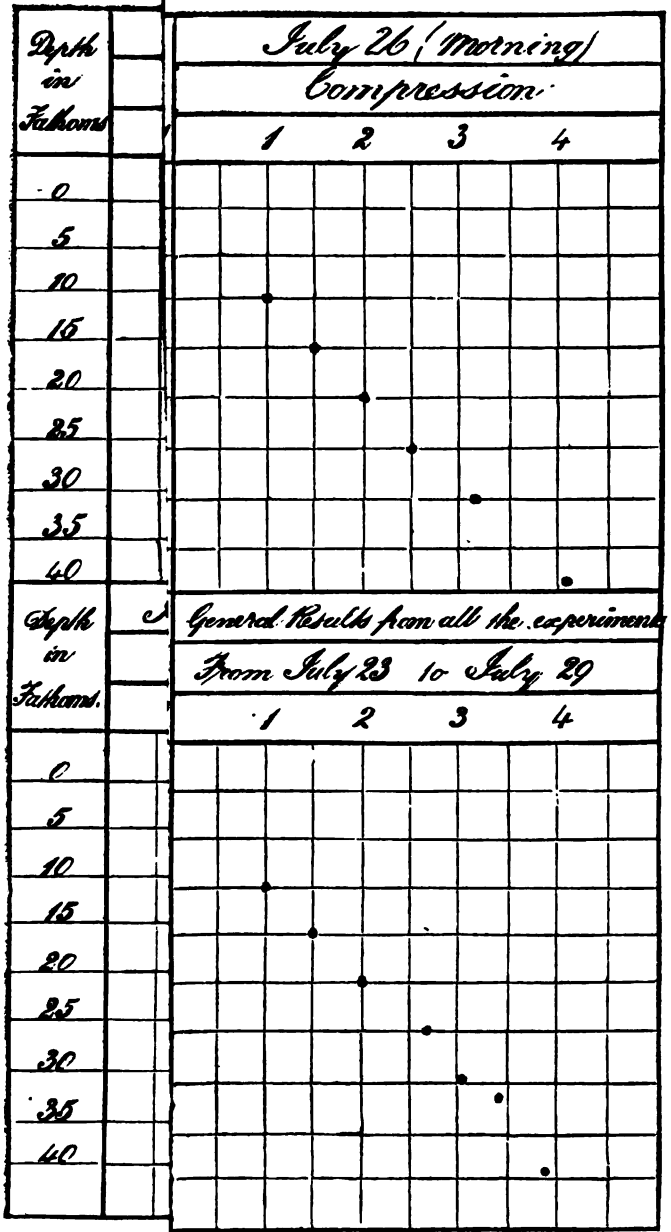
| | | | | | |
|---|---|---|---|---|---|
| 8 | were | made | at the depth of | 10 | fathoms. |
| 13 | " | " | " | 15 | " |
| 7 | " | " | " | 20 | " |
| 7 | " | " | " | 25 | " |
| 8 | " | " | " | 30 | " |
| 22 | " | " | " | 33 | " |
| 12 | " | " | " | 40 | " |

The results of experiments are shown in the annexed diagram. On every occasion the compression at the greatest depth was recorded, and appeared to be nearly in proportion to the depth. The ratio of compression for sea-water, which has a density of 1.027 equal to the density acquired by fresh water, according to Mr. Perkins's experiments, under a pressure of about 500 atmospheres, appears to be $\frac{1}{20,000}$ part for a depth of 10 fathoms—in the moderate available depth for experiments.

These experiments are considered to have established the principle of the instrument as sound. Still, a series of experiments at greater depth appears necessary to test the instruments under various conditions of depth, temperature, &c., and also to construct a table of depths to be used in deep-sea soundings, and which can be arranged in fathoms.

The deep-sea thermometer is intended to be used at the same time with the deep-

[To face p. 26.


Depth in Fathoms
July 26 (Morning)
Compression
1
2
3
4
0
5
10
15
20
25
30
35
40
Depth in Fathoms.
General Results from all the experiments
From July 23 to July 29
1
2
3
4
0
5
10
15
20
25
30
35
40

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sea pressure-gauge, in order to supply any correction required for variation of the volume of water in it through change of temperature.

However, it has been suggested by Captain Davis that, to render this instrument independent of this calculation, it should be placed previous to use in water of about the temperature of the air, so as to acquire this temperature, and the same action repeated after use and before reading off.

Variation in the Volume of Sea-Water, boiled to free it from air, with change of temperature. Thermometer 67°·5 Fahr. Barometer 29·92 inches.

| Deg. | No. of Parts. | Deg. | No. of Parts. | Deg. | No. of Parts. |
|---|---|---|---|---|---|
| Fahr. | | Fahr. | | Fahr. | |
| 86° | 20000·0* | 64° | 19930·0 | 42 | 19888·0 |
| 85 | 19996·0 | 63 | 19927·5 | 41 | 19886·7 |
| 84 | 19992·5 | 62 | 19925·0 | 40 | 19885·5 |
| 83 | 19989·0 | 61 | 19922·5 | 39 | 19884·5 |
| 82 | 19985·5 | 60 | 19920·0 | 38 | 19883·5 |
| 81 | 19982·0 | 59 | 19917·5 | 37 | 19883·0 |
| 80 | 19978·5 | 58 | 19915·0 | 36 | 19882·5 |
| 79 | 19975·0 | 57 | 19913·0 | 35 | 19882·0 |
| 78 | 19971·5 | 56 | 19911·0 | 34 | 19881·5 |
| 77 | 19968·0 | 55 | 19909·0 | 33 | 19881·0 |
| 76 | 19964·7 | 54 | 19907·0 | 32 | 19880·5 |
| 75 | 19961·5 | 53 | 19905·0 | 31 | 19880·0 |
| 74 | 19958·25 | 52 | 19903·0 | 30 | 19880·0 |
| 73 | 19955·0 | 51 | 19901·0 | 29 | 19880·0 |
| 72 | 19951·5 | 50 | 19899·0 | 28 | 19880·0 |
| 71 | 19948·0 | 49 | 19897·0 | 27 | 19880·0 |
| 70 | 19945 0 | 48 | 19895·0 | 26 | 19880·0 |
| 69 | 19942·5 | 47 | 19894·0 | 25 | 19880·0 |
| 68 | 19940·0 | 46 | 19892·5 | 24† | 19880·0 |
| 67 | 19937·5 | 45 | 19891·0 | 23 | 19880·0 |
| 66 | 19935·0 | 44 | 19890·0 | 22 | 19880·0 |
| 65 | 19932·5 | 42 | 19889·0 | | |

*Remarks on a new Telemeter; a new Polarimeter; a new Polarizing Microscope; and various Spectroscopes.* *By* M. HOFMANN.

*On the North Atlantic Telegraph.* *By* N. J. HOLMES.

The author described a projected line of telegraphic communication between England and America *vid* Scotland, the Faroe Isles, Iceland, Greenland, and the coast of Labrador, and known as the North Atlantic Telegraph. A glance at the map in the direction pointed out will at once show that convenient natural landing stations exist, breaking up the cable into four short lengths or sections. Not only will this subdivision of the cable diminish mechanical risks in submerging, but the retardation offered to the passage of the current through the several short sections is almost as nothing when compared with that of an unbroken length of 2000 miles. The average depth of the ocean between Scotland and the Faroe Isles is only 150 fathoms, the greatest depth 683 fathoms. Between the Faroes and Iceland 250 fathoms, with about the same maximum depth. Between Iceland and Julianshaab, the intended landing-place of the cable in Greenland, the greatest depth is 1550 fathoms; and between Greenland and Labrador rather over 2000 fathoms. These lengths of cable and depths of ocean are both not only manageable but practicable, and no difficulties in the working exist that are not already known by reference to the practical working of existing cables under the conditions

* The volume at 86° being considered as unity, and divided into 20,000 parts.

† A gentle motion kept up to equalize the temperature of the sea-water has prevented its freezing at 28°·5.

other times this ice breaks up, and the coast is accessible to the Danish and other trading vessels frequenting the port and harbour of Julianshaab, the proposed station and landing-place of the cables, and at such times the cables will be laid. Reference to the depth of the soundings up the Julianshaab Fjord will at once indicate the security of the shore-ends of the cables from interference by ice when submerged. The landing-places of the cables in Iceland are likewise in no way liable to be disturbed by ice of such a nature as to cause damage to the cable; and on the Labrador coast the risk of injury to the cable cannot be considered greater than that to which the Anglo-American telegraph shore-ends are exposed in the vicinity of the Newfoundland bank.

*On a Defect in the Demonstrating Polariscope, with a simple and effective Remedy.* *By* J. T. Taylor.

## CHEMISTRY.

*Address by* H. Bence Jones, *A.M., M.D., F.R.S., President of the Section.*

From the foundation of the British Association in 1831, I believe no practising physician has been President of the Chemical Section; and I cannot take this chair, when I know there are so many around me much better qualified than I am to lead and to direct the discussions that will take place on various papers that will be read, without asking your extreme indulgence for my shortcomings when subjects are before you which will be far above the direction of my inquiries.

When, however, I consider that my presence here may be regarded as a slight evidence of the relationship that exists between chemistry and medicine, I am encouraged in my undertaking by the thought, that whatever sets forth the union of chemistry and medicine tends to promote not only the good of science but also the welfare of mankind.

For centuries this union has been at one time admitted and at another disallowed; but in the last half-century the discovery of Dr. Bright has proved that chemistry is absolutely requisite for the detection of a large class of diseases, and that without chemistry the nature of these diseases cannot be understood.

Moreover, since this great discovery the action of different chemical substances on the different forces in the different living textures, as, for example, in the muscles and nerves, has been so far investigated by chemists, that it is daily becoming more and more certain that not only must every medical man become a chemist if he wishes to have any clear idea of the action of air, food, and medicine, but that the chemist who has most knowledge of the different forces that act in the body will require to learn the forms of matter in which those forces reside, and then with tentative skill he will quickly be able to regulate the qualitative and quantitative errors which constitute disease. In other words, when the union of chemistry and medicine is perfect, then science will show us how to keep or to regain the greatest of blessings, health.

The past year has not for chemistry been a year of great progress, though the harvest of new truths has been quite equal to the average.

That grand field for discovery, the synthesis of organic substances, furnishes as usual the most important fruit; and, as in duty bound, let me first mention the results that have been obtained by Professor Frankland at the Royal Institution.

His synthetical researches on ethers have partly been published in the Philosophical Transactions. He has succeeded in replacing all three atoms of hydrogen in the methyl of acetic acid by alcohol radicals; and thus he has obtained a third kind of butyric acid, namely, di-meth-acetic acid, $\left\{\begin{matrix}CMe_2H\\CO\,Ho\end{matrix}\right.$, and a new valerianic acid, namely, tri-meth-acetic acid, $\left\{\begin{matrix}CMe_3\\CO\,Ho\end{matrix}\right.$; also iso-lauric acid, $\left\{\begin{matrix}C\,Ay_2H\\CO\,Ho\end{matrix}\right.$.

The same reaction has also been extended to the replacement of the hydrogen of

* For a full explanation of these formulæ, *vide* Journ. Chem. Soc. 1866, pp. 372 *et seq.*

acetic acid by isopropyl, and an entirely new series of compounds containing this radical has thus been obtained. One of these forms a second new valerianic acid, namely, isopropyl-acetic acid, $\left\{\begin{matrix} C\ Pr\beta\ H_2 \\ CO\ Ho \end{matrix}\right.$. The numerous compounds of this beautiful series have not yet all been examined and submitted to analysis, and hence these results are still unpublished.

Taken together, the data furnished by this investigation establish beyond doubt the internal architecture of the fatty acids, placing the constitution of these bodies on as certain a basis as that of the compound ammonias synthetically investigated by Hofmann.

Professor Frankland has also continued his researches with Mr. Duppa on the synthesis of acids of the lactic series.

M. Persoz and Professor Maxwell Simpson have added still further to our knowledge on the synthesis of organic acids; and Professor Hofmann, notwithstanding his engagements in superintending the building of two grand laboratories for the promotion of chemical research, has found time to send us the synthesis of guanidine.

Before leaving this subject of synthetical chemistry, I must mention Professor Roscoe's paper on the "Chemical Intensities of Sunlight," for this is the direction in which the chemist looks for the glorious climax of all his synthetical investigations—the discovery of the chemical architecture of substances in the vegetable world.

The next grand field of investigation, analysis, seems comparatively deserted now. A most remarkable discovery has been made by the Master of the Mint on the absorption and dialytic separation of gases by colloid septa; for example, he finds that mixed gases pass through india-rubber at different rates proportioned to their power of liquefaction. The oxygen of atmospheric air passes through rapidly, whilst the nitrogen is comparatively stopped. The importance of this discovery in metallurgy, and its application to the physiology of respiration and of the passage of oxygen from the blood into the textures, must be apparent to all. Mr. Vernon Harcourt has begun to estimate quantitatively the effect of time in influencing the amount of chemical change; or more generally, the laws of connexion between the conditions of a chemical change and its amount. Then we have new researches on gun-cotton, and a new series of hydrocarbons has been extracted from coal-tar. Some further spectrum analyses have been made by Mr. Huggins: among these are the analyses of comets and of the new star in Corona Borealis, of which the author will give you his own account; and lastly, in physiological chemistry we have an important paper on animal heat, by M. Berthelot, being the third memoir of his researches on thermo-chemistry; and a most valuable work on colouring-matters and extractive matters of the urine, by Dr. Schunck; and a paper on the detection of an alkaloid fluorescent substance like quinine in the different structures of the body, by Dr. Dupré and me.

Pardon my egotism if for a moment I dwell on my own subject, when you may consider other subjects are far more deserving of further remarks.

It seems but a few years ago when we were taught that the animal and vegetable kingdoms were composed of entirely different kinds of substances. Nitrogenous compounds were said to belong to the animal kingdom, and the vegetable kingdom was said to be formed of carbonaceous matters only. The ammoniacal products of the gas-works were considered curious; and only from the time of Professor Liebig's investigations do we date our knowledge of the all-pervading presence of albuminous substances in vegetables. We can now see plainly that this was the death-blow to all chemical distinction in the composition of vegetables and animals.

But no wrong knowledge is easily set right. First starch, then woody fibre, then colouring-matters like indigo, then alkaloids like quinine were one after the other thought to distinguish the vegetable from the animal creation, and each of these substances or their representatives have at last been found in animals. Even protagon, which was thought to belong only to the nerves of animals, has been found by Hoppe in maize and other cereals to the amount of 0·149 per cent. So that really at the present time no chemical distinction whatever between vegetables and animals can be made. And except in the mode in which these different substances are produced in the two kingdoms of nature, no chemical difference exists.

This is seen in the following two columns of substances, and to each column must now be added Protagon.

| Formed synthetically, | and | Formed analytically. |
|---|---|---|
| Oxalic acid. | | Albumen. |
| Formic acid. | | Casein. |
| Lactic acid. | | Animal quinoidine. |
| Acetic acid. | | Indican. |
| Valerianic acid. | | Glycocol. |
| Glycerine. | | Taurin. |
| Sugar. | | Leucin. |
| Starch. | | Urea. |
| Cellulose. | | Caprylic acid. |
| Cholesterin. | | Caproic acid. |
| Butyrin. | | Capric acid. |
| Palmitin. | | Olein. |
| Stearin. | | Stearin. |

| Formed synthetically, | and | Formed analytically. |
|---|---|---|
| Olein. | | Palmitin. |
| Capric acid. | | Butyrin. |
| Caproic acid. | | Cholesterin. |
| Caprylic acid. | | Cellulose. |
| Urea. | | Starch. |
| Leucin. | | Sugar. |
| Taurin. | | Glycerine. |
| Glycocol. | | Valerianic acid. |
| Indican. | | Acetic acid. |
| Quinine. | | Lactic acid. |
| Casein. | | Formic acid. |
| Albumen. | | Oxalic acid. |

Let me for an instant point out to you what a vast field for analytical discovery lies open here to the chemistry of the future.

Various processes of oxidation, hydration, dis-hydration, and splitting, taking place at a temperature below 100° F., produce in animals a multitude of compounds which lie between albumen and carbonate of ammonia. The analytical chemistry of the future will some day be able to form from albumen all these descending compounds, as surely as we are now progressing by synthetical discovery to the formation of all the compounds that are put together by the synthetical chemistry of vegetables; and as the synthetical chemist is already surpassing nature by forming combinations which vegetable life has never yet produced, so the analytical chemist of the future will probably from albumen educe innumerable compounds, which in the tissues and secretions of animals have never been known to occur.

It is the special function of the British Association to popularize science and to interest the public generally in the discovery of scientific truth. This Association is in fact a means of education. It was intended to promote the diffusion of natural knowledge among the people, because it was considered that that knowledge surpassed all other knowledge in its usefulness and benefit to mankind.

From its relationship to the public, the British Association is more interested than any other Society that exists in hastening the time when education in natural knowledge will be at least as general as the education in classical knowledge now is.

My predecessor, Professor Miller, last year told you that "some years will no doubt elapse ere science is admitted to take equal rank as a means of education with the study of classical literature. Still it is but a question of time." "The practical instinct of the nation is becoming alive to the necessity of making certain portions of the training of our youth consist in the systematic study of the elementary parts of properly selected branches of science."

Although we may say with Mr. Gladstone that time is on our side, and although we are beginning to ask how our present formula for education has arisen, and why it remains almost unchanged whilst all natural knowledge is advancing, and although an entire change in everything except the highest education has taken place, yet public opinion is affected so slowly, and the prejudices of our earliest years fix themselves so firmly in our minds, and the belief we inherit is so strong, that an education far inferior to that which a Greek or a Roman youth, say twenty centuries ago, would have received, is the only education fit to make an English gentleman, that I consider it is of no use, notwithstanding the power which this Association can bring to bear on the public, to occupy your time with the whole of this vast question.

But there is an outlying portion of this subject which personally touches each one of us here present, and this with much diffidence I venture to bring before this Section of the British Association.

I allude to the present state of education in natural knowledge of that portion of the community who may at any moment be asked to tell any of us here present, what mechanical means should be used to lessen or increase the mechanical actions of the body, and what chemical substances should be taken to lessen or increase the different chemical actions within us, when they rise or fall to such a degree as to constitute disease.

I know well that no expression of opinion can be given collectively by this Chemical Section on the necessity for a preliminary education in chemistry and physics of those who undertake, first to understand, and then to give advice on the errors of oxidation, digestion, secretion, and nutrition of our bodies; but I may, perhaps, lead you individually to consider this subject, and to bring your influence to bear upon this question as being at the root of a great change, which may bring a direct benefit to us and to our children in helping us to procure and to preserve our health; whilst it will lead to an increase in the number of those who are looked on with great favour by the British Association: I mean the individual cultivators of natural knowledge.

In order that you may see clearly what is wanted, I will contrast the present state of medical education with that reasonable knowledge, which I am quite sure every one in this Chemical Section will say ought to be possessed by those who attempt to understand and to regulate an apparatus that works only whilst oxygen is going into it and carbonic acid is coming out of it.

I will, as shortly as possible, put before you the present education of those who practise medicine.

The present higher education for the medical profession consists, shortly, in learning reading, writing, and arithmetic in the first ten years of life. In the second ten years, Latin, Greek, some mathematics or divinity, and perhaps some modern language. In the third ten years, physics, chemistry, botany, anatomy, physiology, and medicine, and perhaps surgery.

Looking at the final result that is wanted, namely, the attainment of the power of employing the mechanical, chemical, electrical, and other forces in all things around us for increasing or diminishing the mechanical, chemical, and other actions taking place in the different textures of which our bodies are composed, it is quite clear that the second decennial period is passed without our advancing one step towards the object required; and that in the third decennial period the amount to be learned is very far beyond what is possible to be attained in the time allowed.

In the first eighteen years of life, reading, writing, and arithmetic, and enough Latin to read and write a prescription constitute the minimum to be acquired. During the next three years, physics, chemistry, botany, anatomy, physiology, and the practice of medicine, surgery, and midwifery have all to be learned, and from this crowding it follows that the study of physiology is begun at the same time as the study of physics and chemistry. In other words, the structure and the foundations are commenced at the same time. The top of the house may be almost finished when part of the foundations has not been begun.

What chance is there of any one understanding the actions of the chemical, mechanical, and electrical and other forces in the body, until a fundamental knowledge of chemistry, mechanics, and electricity has been first obtained? What chance has a medical man of regulating the forces in the body by giving or withholding motion, food, or medicine with any reasonable prospect of success, when a preliminary education in these sciences is thought to be of no importance?

It seems to me that the only possible way to make the present preliminary education for medical men less suited to the present state of our knowledge, would be to require them to know Hebrew or Arabic instead of Latin, in order that the origin of some of our words might be better understood, or that prescriptions might be written in one or other of these languages.

Let me now, for contrast sake, draw you a picture of a medical education, based upon the smallest amount of classical knowledge, and the greatest amount of natural knowledge which can be obtained.

In the first ten or twelve years of life, a first-rate education in the most widely used modern language in the world, English, with writing and arithmetic, might

[illegible] and in the next [illegible] a sound basis of knowledge of physics, chemistry, and [illegible] with [illegible] of [illegible] might be introduced: and in the [illegible] the [illegible] [illegible] and medicine, surgery, and midwifery.

[illegible] in the English language, and [illegible] the basis of the course to be followed in the [illegible] [illegible], and if he could use all the forces in nature for the [illegible] of health, and if he could from his knowledge of chemistry and physics, and their application to disease and medicine, become the best authority which could be upon questions connected with the health and welfare of his fellow-men, and if he possessed the power of superintending and directing the [illegible] in the manufacture and investigations which would be required as to the nature and actions of foods and medicines, and as to the products of disease, surely the position and power and advancement of medical men would be very different from that which they now obtain by cramming some Latin and less Greek.

At present so far from physicians possessing more knowledge of food and of medicine than any other class of persons in the community, the analytical and pharmaceutical chemists are usually necessary to knowledge, which will enable them not only to understand fully the nature and uses of food and medicines, but even to detect the first appearances of a multitude of chemical diseases. Their habits of investigation and their knowledge of the nature of the forces acting in the world will gradually lead them to become advisers in all questions regarding the health of the community, and from this they will, like M. Bouchardat, in Paris, become almost, if not all, medical practitioners of medicine.

No doubt chemists are very far from being medical practitioners at present, but remember that there is no limit to human knowledge, and that each moment the chemical knowledge of things around us is progressing, and that chemists are becoming able better to answer every question that can arise regarding the air, water, food, drink, and medicine which, by means of the forces that exist in them, act upon the forces which go to make up the phenomena of health and of disease: while as it is, between the time that might be devoted to acquiring natural knowledge, the authorities who regulate medical education only this last spring have determined that in addition to Latin, every medical man shall possess a competent knowledge of Greek in order that the derivation of hard words may be obtained from the brain instead of a dictionary.

In confirmation of my opinion of the direction in which the treatment of disease is progressing, I may just refer to the cattle-plague, which in 1745 was treated by Dr. Mortimer, at that time Secretary of the Royal Society, and therefore one of the most scientific physicians in the country, with antimony and bleeding. In 1866, two chemists, Dr. Angus Smith, Ph.D., F.R.S., and Mr. Crookes, F.R.S., gave the only useful suggestion for combating the disease, namely, by the arrest or the destruction of the poison by chemical agents.

There is yet another point of view in which chemists will see the harm that results from our present medical education.

The use of Latin in our prescriptions requires that the pharmaceutists should learn at least sufficient Latin to read what we have written. Many errors have arisen, and will arise from the dispenser being unable to give the directions rightly. To avoid such mistakes, a portion of the time that ought to be given to the attainment of the highest possible amount of chemical acquirement, and a perfect knowledge of the English language, or some foreign language, wherein he might learn the discoveries in chemistry, and the improvements in pharmacy of other countries, must be devoted to the learning of Latin in which the physician writes his directions.

All our druggists in England ought to be what they are in Germany and in France, chemists capable of any analysis that might be required of them, and able to satisfy themselves and the medical men that the substances they sell are what they profess to be, pure, unadulterated chemical compounds.

No one of my hearers in this Section will consider five years a long time for the

acquirement of such knowledge, and until the pharmaceutists all obtain this education, medicine will be subject to a great cause of uncertainty in the variations in the quality and quantity of the different substances which, under the same name, are obtained from different druggists.

Before I conclude I must apologize to some in this Section who may think that this subject is of no interest to them, by reminding them that none but chemists can judge what the worth of chemical education really is; and I am sure that no body of scientific men exists who are so fitted to judge of the necessity of an education in natural knowledge for those who employ the forces around us to regulate the forces within us as the Chemical Section of the British Association.

Last year Professor Miller said, "It behoves all who are themselves engaged in the pursuit of science to consider in what way they can themselves aid in forwarding the cultivation of natural knowledge."

I ask you, for the good of science and for your own good, to exert your influence in the first place, and more especially to effect a change in the preliminary education of all those who intend to practise medicine; so that leaving Greek and Latin to be the ornaments and exceptions in their education, they may have time to obtain the best possible knowledge of the chemical and physical forces with which they have to deal. I urge this because of my conviction that whenever the most perfect knowledge of chemistry and physics becomes the basis of rational medicine, then, and not till then, medicine will obtain the highest place among all the arts that minister to the welfare and happiness of man.

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*On the Assay of Coal, &c., for Crude Paraffin Oil, and of Crude Oil and Petroleum for Spirit, Photogen, Lubricating Oil, and Paraffin.* *By* Dr. J. Attfield, *F.C.S., Director of the Laboratory of the Pharmaceutical Society.*

The paper included descriptive details of the methods of examining small specimens of coal, shale, lignite, &c., with the view of determining their value as sources of crude paraffin oil. It also contained instructions whereby to obtain the value of a specimen of crude oil or of petroleum as sources of spirit, photogen, lubricating oil, and paraffin. The author placed no dependence on the process of igniting the coal, &c. in a crucible and taking the amount of volatile matter yielded as an indication of the value of the specimen. He preferred to submit the coal at once to distillation, with certain precautions, in a small iron retort arranged in a peculiar manner. After showing how to best separate and weigh the oil and other products of the distillation so as to avoid loss, the author proceeded to suggest the adoption of uniform operations to ascertain the value of the oil or petroleum. These were mainly operations of fractionation with or without previous distillation, with or without previous purification. The separation of paraffin on the analytical scale of the laboratory was then described, the paper closing with suggestive remarks concerning the nomenclature of the various products.

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*On the Action of Chlorine on Amylene.* *By* Dr. Bauer.

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*On the Purification of Terrestrial Drinking Waters with Neutral Sulphate of Alumina.* *By* Alfred Bird.

The principle upon which this process is founded is based upon the known affinity which hydrated alumina has for organic matters, in combining with them and rendering them insoluble.

The action is as follows:—

One part of neutral sulphate of alumina in solution is added to seven thousand parts of the water to be purified. As soon as the mixture is made, a cloudy haze is seen in the water, which haze rapidly condenses into flocculi, with little lanes of clear water of the greatest brilliancy and beauty between them. As the flocculi become more dense they rapidly descend to the bottom of the water, leaving it absolutely free from all organic colouring-matter, as clear as crystal, and free from taint.

The time required for complete precipitation is from six to eight hours; if, there-

fore, the precipitant be put in over-night, the water will be ready for use in the morning, and as *time* for the action to take place, and not *quantity of water* is the consideration, ten thousand gallons can as quickly be purified by this process as a gallon.

The chemical action is thus:—The lime which is in solution in the water as a carbonate combines with the sulphuric acid of the sulphate, and forms sulphate of lime. The liberated hydrate of alumina instantly attacks the organic matter, which it renders insoluble, and both rapidly descend to the bottom of the water, while the carbonic acid gas which remains in the water imparts to it a sparkling freshness and beauty.

As the liberation of the hydrated alumina depends on the presence of carbonate of lime in the water, and as its *absence* in terrestrial waters is a most rare occurrence, the applicability of this precipitant for the purification of terrestrial waters may be said to be universal.

In order to test the effect of the precipitant upon very dirty water, a gallon was taken out of the Thames at half-tide, in the centre arch of London Bridge. Into this water was put twenty drops of a standard solution of the precipitant. The water was then allowed to stand eight hours, when it was found that all the filth had settled to the bottom, and the supernatant water was clear, sparkling, and pleasant to drink.

The author has therefore the greatest confidence in recommending the precipitant for purifying the water contained in ships' tanks, and the waters taken from tropical rivers and ponds, which in their natural state it is impossible to drink, in consequence of the decaying organic matter contained therein, being a direct incentive to cholera. If to such waters the precipitant be applied, they can be rendered as perfectly salubrious as water taken from the deepest wells. The same effect can be produced by the precipitant on tainted well-water, and the waters of stagnant ponds which are left for the use of cattle in the corners of fields.

For testing the superior salubrity of water which had been purified with the precipitant over the *same water* which had *not* been so purified, various experiments were detailed.

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*On the Oxidizing Action of Carbon.* *By* Dr. Crace-Calvert, *F.R.S.*

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*On Disinfection.* *By* William Crookes, *F.R.S.*

As an illustration of the want of general knowledge of the laws of disinfection, and the evils resulting from the absence of combined action between the local self-governing authorities, I may refer to what is being done in London in reference to the present outbreak of cholera. The drainage of one thousand acres, saturated with a powerfully *oxidizing* disinfectant, mingles in the sewers with the drainage from another thousand acres, to which a powerfully *deoxidizing* agent has been liberally applied, the result being that an enormous amount of money is expended on various disinfectants and deodorizers, with very inadequate results; and many valuable agents may ultimately fall into discredit from the want of a few simple discriminating rules for their proper application. Disinfecting agents of great value are being used for purposes for which they are totally unfit; useful but incompatible disinfectants are recommended in the same paper of instructions; and chemicals of the most potent description are given to ignorant persons without a word of warning as to how they are to be applied.

Disinfection is by no means so simple a process as is generally supposed. Chemists are aware that we cannot use one substance with equal efficacy in all imaginable cases. The process is one depending upon complicated chemical and physiological actions; and chemistry has placed at our disposal several substances which are applicable to various requirements of the case; but to pin one's faith to one agent only, be it carbolic acid, chloride of lime, Condy's fluid, or McDougall's powder, is to limit one's powers of disinfection in a very unwise degree; whilst to recommend all these things without discriminating in what cases they are severally to be used, is like sending a sick man to a druggist's shop, telling him neither what special drug to take, nor how much for a dose.

It is highly important that the best plan of disinfection adapted to the present, or like emergencies, should be definitely settled by some competent authority, and its adoption then made uniform throughout the country. The various disinfectants ought always to supplement each other, so that when the contents of the adjacent sewers blend together, the purifying action of the disinfectants used should pervade the mass.

The word "disinfectant," in its ordinary sense, implies a body which will destroy an animal poison or virus, in whatever way it is accomplished; in a more restricted sense, the term is used to indicate an agent which destroys organic or offensive matter by oxidation or analogous action; whilst under the term "antiseptics" are classed those agents which arrest poisonous action by destroying the tendency to putrefy, and stopping chemical change.

*Oxidizing* disinfectants—those which actually burn up organic matter by means of combined or atmospheric oxygen—are by far the best known and most used; inasmuch as they appeal directly to popular prejudice, by destroying the foul odours which are the usual accompaniments of infection, whilst "*antiseptics*" have little or no action on these gases. This fallacious mode of estimating their relative value is one which does great injustice to antiseptics.

In the search for disinfectants suitable to arrest the progress of a zymotic disease, it is necessary to strike off at once a whole class of valuable agents which will not meet the requirements of the case. It is more than probable that the infectious matter partakes of the physical properties of a vapour or of fine dust; and it is consequently hopeless to attempt to combat the virus by non-volatile disinfectants. For this reason, charcoal, chloride of zinc, the permanganates, solutions of metallic salts, and other similar substances are of limited use: what is wanted for general purposes, is a liquid and a volatile disinfectant, which, after first acting on infected surfaces, will, by gaseous diffusion, pervade the infected atmosphere, and destroy the floating virus.

At first sight the action of a powerful oxidizing-disinfectant, like chloride of lime, or Condy's fluid, upon noxious vapours or even septic germs, appears perfect. In presence of an excess of either of these agents, all organic impurity is at once burnt up, and reduced to its simplest combinations; and could we always rely upon the presence of a sufficient amount of either of these bodies, no other purifiers would be needed. But in practical work, these disinfectants are always very inadequate, except for a short time after their application; at other times, the oxidizing agent has presented to it far more noxious material than it can by any possibility conquer; and being governed in its combinations by definite laws of chemical affinity, the sulphuretted and carburetted hydrogen, the nitrogen- and phosphorus-bases, and other vapours of putrefaction, will all have to be burnt up before the oxidizing agent can touch the germs of infection; whilst the continued renewal of the gases of putrefaction will constantly shield the infectious matter from destruction.

This is the chief objection to disinfectants which act by oxidation. If we arrange in a series the possible substances which may be present in an infected neighbourhood, and gradually mix with them chlorine or a permanganate, we find that these vapours, which have strong and fœtid odours, and which we will place at the commencement of the list, are the first to go; whilst the actual virus of the disease—the organized particles which have little or no odour—are the last to be attacked. It so happens that the stinking gases of decomposition are of comparatively little danger, whilst the deadly virus-cells of infectious diseases are inappreciable to the sense of smell. Again, oxidizing disinfectants possess little or no permanent action. What they attack is destroyed perfectly, but what they leave has no special resistance to decomposition conferred upon it. They remove the products of decomposition, but they do not take away the power of subsequent decomposition. Mere deodorization therefore is no protection whatever.

Oxidizing disinfectants produce their effect by the actual destruction of the infecting substance. Antiseptics act by destroying its activity. The former act more energetically upon dead than upon living organic matter. Antiseptics attack first the opposite end of the list, and commence by destroying vitality. They exert little or no action on the foul-smelling but comparatively harmless gases of decom-

position, whilst they act with intense energy on the inodorous germs of infection which these gases may carry into the atmosphere along with them.

If, therefore, the matter which conveys infection from one person to another be of the nature of an organized germ, if its tremendous powers of destruction are due to its vitality, then antiseptics are the only agents fitted to deal with these special cases; for whilst they leave almost untouched the majority of simply odorous gases, they seek out and destroy the one thing to be feared.

Now, of all antiseptics, those known as the tar acids, are the most powerful; and of these, commercial carbolic acid may be regarded as the representative. The powerful action which carbolic acid exerts on the phenomena of life, is the most remarkable property which it possesses. It may be looked upon as the test proper for distinguishing vital from purely physical phenomena; and in most cases its action is characterized by the certainty and definiteness of a chemical reagent. In the presence of carbolic acid the development of embryonic life is wellnigh impossible; and before its powerful influence all minute forms of animal existence inevitably perish. The vapour of carbolic acid in the atmosphere exerts a specially selective power on all minute organisms possessing life. If the infectious matter of cholera is possessed of organic vitality, as is now almost universally admitted, it will be destroyed beyond the possibility of revival, when brought in contact with this vapour.

Although the properties of carbolic acid are so valuable, the error I have already alluded to must be avoided, of considering it applicable to every case where disinfection is requred. Whilst its peculiar properties render it of wide applicability, it may on many occasions advantageously be replaced by other disinfectants. Thus, for purifying water for drinking or culinary purposes, it is far inferior to ebullition in the presence of Condy's fluid, which acts in this respect perfectly. Again, the liquid nature of carbolic acid renders it not so appropriate as McDougall's or Calvert's powder for many purposes, an excess of liquid being frequently a disadvantage where large quantities of solid offensive matter have to be dealt with, in which case either of the powders above mentioned is more suitable than carbolic acid.

Although much more expensive than carbolic acid for equal amounts of purifying work, chloride of lime also is a more appropriate agent where mere deodorization is the chief desideratum.

It has been assumed, I think on insufficient grounds, that the mere addition of permanganate of potash to drinking-water will certainly destroy the cholera virus. The oxidizing powers of this agent, although very energetic on dead organic matter, are successfully resisted by living organisms. Animalcules will live without apparent inconvenience for some time in water tinted with permanganate; and, assuming that the cholera poison possesses organic vitality, we have no guarantee that the agent in question will effect its destruction. For this reason, I should be inclined to prefer boiling the water after adding permanganate.

Let me here state a fact which ought to be generally known in respect to carbolic acid. For disinfecting purposes, as ordinarily applied, it is very extravagant to use it in the undiluted form. Except in special cases, the aqueous solution of the acid should invariably be used. Water will dissolve about 4 per cent.; and for most purposes this solution is a better disinfectant than the undiluted acid. A small insect which is killed in a few seconds by immersion in the 4 per cent. aqueous solution, will live for a minute or more when covered with the undiluted acid. When the aqueous solution is added to sewage, the latter is at once disinfected; but on adding to a similar quantity of liquid far more than the corresponding amount of undiluted acid, this sinks, as a heavy oil, to the bottom, where it remains; and unless the mixture be well shaken, so as to bring the oil in contact with every portion, complete disinfection will not be effected for some time. To throw undiluted carbolic acid down the drains, as is done in many places at the present time, is simply to throw money away.

Allow me, in conclusion, to draw attention to the great importance of the scientific prosecution, by qualified persons, of accurate experiments and observations in reference to the cholera, similar to those undertaken in respect to the Cattle Plague. The third report of the Cattle-Plague Commission has given us more insight into that pestilence than we possess of any human zymotic disease; and there is no

reason why a similar plan should not be carried out in this instance. The subject is so serious, that its treatment with regard to disinfection ought not to be decided by analogies between cattle plague and cholera, which are yet unproved. In a visitation of this character it is possible to try experiments of a nature wholly out of our power under ordinary circumstances; and thus it is feasible to suppose that, from the lessons derived from this pestilence, we might obtain insight into the laws governing zymotic diseases.

Although foul sewage and putrefying animal matter are probably insufficient to generate the first septic germ of a pestilence, there can be no question that when such a plague does come amongst us, it spreads with the greatest virulence wherever such putrescent materials abound. It may therefore be expected, not unreasonably, that by extending the sphere of an operation of appropriate disinfectants, we may diminish the death-rate, and materially augment the well-being of the community.

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### *On Ozone.* *By* Dr. Daubeny, *F.R.S.*

Dr. Daubeny communicated a summary of the observations and experiments he had been making with respect to the presence of ozone in the atmosphere, the sources from which it was derived, and its uses in the economy of nature. Judging from the depth of coloration produced upon Schönbein's papers by exposure to the open air, as observed during a period extending on the whole to eight months, he inferred that the quantity of ozone at Torquay was much greater, on the average, during the prevalence of winds proceeding from the sea, than at times when they had blown over land. By the same test he had endeavoured to ascertain whether this ozone was generated by vegetation; and although he found that light alone exerted some influence in colouring the paper, in proportion to its intensity, was led to infer that, after deducting this, a certain residual effect was due to the action of the green parts of plants in generating ozone during the day; and as ozone exercises an undoubted power in removing putrid matter by oxidation, it seemed probable that the vegetable world may be thus the appointed means of destroying animal effluvia, and of thus restoring to the atmosphere its original purity when vitiated by the emanations of living beings.

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### *On the Refraction- and Dispersion-equivalents of Chlorine, Bromine, and Iodine.* *By* J. H. Gladstone, *F.R.S.*

The refraction-equivalent of a substance is the product of its atomic weight into its specific refractive energy, that is, its refractive index minus one divided by its density. From data previously published by the author and the Rev. T. P. Dale, together with Dulong's observations on gases, the following determinations of the refraction-equivalents of the halogens had been made.

*Chlorine*, as a gas, or in gaseous combination, gives the number 8·7; in the chloride of phosphorus it seems to be 9·4; while in several cases of its liquid compounds of carbon and hydrogen it ranged from 9·6 to 10.

*Bromine*, as the elementary liquid, gives the number 16·6; its liquid compound with phosphorus indicates only 14·5, and its compounds with carbon and hydrogen about 15·5.

*Iodine*, as determined from four liquid compounds of the iodide-of-methyl series, averages 24·2.

The numbers determined for bromine are nearly intermediate between those for chlorine and iodine.

The dispersion-equivalent of a substance is the difference between its refraction-equivalents as calculated for the two extreme lines of the spectrum A and H. Determinations from some of the same compounds of the halogens with methyl, ethyl, &c., gave numbers, of which that for bromine lies also between those of the other two, but considerably nearer to chlorine than to iodine. The following determinations are strictly comparable:—

| | Chlorine. | Bromine. | Iodine. |
|---|---|---|---|
| Refraction-equivalents..... | 9·8 | 15·5 | 24·2 |
| Dispersion-equivalents..... | 0·5 | 1·3 | 2·6 |

*On the Nature and Properties of Ozone and Antozone demonstrated experimentally.* *By* J. M. McGAULEY.

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*On the Chemical Action of Medicines.* *By* Dr. H. BENCE JONES, *F.R.S.*

The law of the conservation of energy entirely does away with every supposition that medicine can create or annihilate any force. Medicines may carry latent energy into each part of the body, and they may become active within by increasing oxidation, nutrition, secretion, motion, and sensation; or by their properties they may put a check upon these functions by increasing the resistance or by altering the conditions necessary for the conversion of latent energy into active force.

The great functions of medicine are chemically to assist qualitatively or quantitatively, first the working, and secondly, the repair of the organs and structures of the body.

For clearness, only two of the chemical actions of medicines are dwelt on in this paper, namely, their influence on the two processes of oxidation and of nutrition that continually take place in each of the textures of the body. These processes are affected by medicines in at least two ways. First, directly, by the passage of the medicines into the different textures, where oxidation is promoted or retarded, and where nutrition is assisted or muscles prevented; and secondly, indirectly, by the action of the medicines on the nerves that regulate the circulation, whereby the flow of blood through the vessels is increased or diminished. The motion equals the force of the heart divided by the resistance $M = \frac{F}{R}$.

On this view, the first great division of medicines consists of those which (A) directly or (B) indirectly promote oxidation, or (C) directly or (D) indirectly retard it.

A. Medicines that directly promote oxidation,—Iron; oxygen and ozone; alkalies; chlorine, iodine, bromine; permanganates?, iodates, chlorates?, nitrates?, strong mineral, vegetable and animal irritants, as large doses of salts of antimony, copper, zinc, mercury; croton oil; cantharides; all forms of motion, including heat, light, and electricity.

B. Medicines that indirectly promote oxidation by increasing the circulation. Among the causes that determine the force and the frequency of the heart's contraction are, (1) the action of the nerves, (2) of the muscle, and (3) the chemical and mechanical quality and quantity of the blood, and its relative proportion to the system of vessels in which it is contained.

For stimulating or checking the centre of the circulation a most highly complex system of nerves exists, and a similar controlling power over the arterial capillaries exists throughout the periphery.

There are at least four different centres of nervous action for the regulation of the heart. 1. A stimulating or musculomotory centre in the heart itself; 2. an inhibitory centre there also; 3. a centre which acts through the ninth pair of nerves; and 4. another with opposite action, which acts on the heart through the sympathetic nerve. Medicines may act chemically on any or all of these centres, and thereby stimulate or check the heart's action. Thus, for example, digitaline acts on the centre which affects the heart through the ninth pair, for when these nerves are divided digitaline has no action on the heart.

The experiments of Claude Bernard on the sublingual salivary gland show the antagonistic action of the sympathetic and the chorda tympani. Stimulation of the sympathetic checks circulation through the gland; whilst stimulation of the chorda tympani increases the flow of blood, by which secretion and oxidation are increased also.

C. Medicines that directly retard oxidation. To this class belong all the remedies which were included in the antiphlogistic regimen. Vegetable salines; vegetable acids; mineral acids; substances which become organic acids in the system, as sugar; preparations of lead; oxide of carbon; sulphuretted, arseniated, antimoniated hydrogen; oxide of nitrogen; rest from all kinds and forms of motion, mechanical, thermal, electrical, photal.

D. Medicines that indirectly retard oxidation. These may be divided into (1) those that act upon the nerves, as prussic acid, morphia, and many other alkaloids; (2) those that act on the muscles, as rest, cold, salts of potass, lead salts, veratrine, digitaline, nicotine; (3) those that alter the qualitative and quantitative relationship of the blood to the vessels, as local and general bleedings, starvation, dilution, evacuation.

The second great division of medicines consists of those which (E) directly or (F) indirectly promote nutrition, or (G) directly and (H) indirectly retard it.

The chemical actions which are concerned in the formation of the multitude of organic substances of which the body is composed are far more complicated than those comparatively simpler chemical actions on which oxidation depends. If even now the different steps and processes, the helps and hindrances which affect the formation of carbonic acid and water in the body are not yet determined, how much less able must we be at present to comprehend the chemical actions which take place in the formation of blood-globules, bones, muscles, nerves, &c.

Many of those medicines that promote or retard oxidation at the same time promote or retard nutrition. When they are present in excess, they render the formation of different substances more rapid; and when absent, the chemical actions necessary for the formation of these substances are retarded or altogether stopped.

E. Medicines that directly promote nutrition. Iron helps to form blood-globules; phosphate and carbonate of lime help to form bone; cod-liver oil and other fatty matters help to form adipose tissue. Gelatine perhaps helps to form cellular tissue; and phosphorus, still more doubtfully, promotes the formation of nervous tissue.

F. Medicines that indirectly promote nutrition (1) by increasing the action of the heart, (2) by lessening the resistance in the capillaries.—Alcohol, ether, chloroform, nitrous oxide, chloride of methyl, olefiant gas increase the action of the heart by acting on the nerves. Ammonia almost immediately deprives motor nerves of their power of exciting motion, while it intensely irritates the muscular structures. Of medicines that cause the capillaries to dilate curare is the most remarkable.

G. Medicines that directly retard nutrition, either (1) by themselves entering into combination with the organic substances of which the textures are composed, by which combination the chemical changes that would otherwise occur are stopped, or (2) by the accumulation in the textures of any of the substances resulting from the chemical changes in the textures.

Lead, zinc, silver, copper, arsenic, antimony, and in some rare cases mercury, act in small doses in the first way. Among the substances which act in the second way must be included all the different products from each texture in their downward course to carbonate of ammonia, water, and salts. Among these substances carbonic acid and carbonic oxide; organic acids from oxalic acid upwards; sugar; fat; nitrogenous substances from carbonate of ammonia, urea, kreatine, indigo; animal quinoidine, to the first products formed from the albuminous substances.

H. Medicines that indirectly retard nutrition by lessening the action of the heart and increasing the resistance in the capillaries, by which actions the flow of blood through the textures is lessened.

Four different actions may be distinguished, by any of which nutrition may be lessened:—1. By an action on the nerves of the heart, as by strychnia, nicotine, conicine, digitaline; 2. by an action on the muscular structure of the heart, as by veratrine, colchicine, salts of potass; 3. by contraction of the capillaries in consequence of an action upon the sympathetic nerve, as by morphine; 4. by the reduction, quantitatively or qualitatively, of the state of the blood, as by bleeding, starvation, excessive dilution, lead salts, mineral and organic acids.

The actions of oxidation and nutrition are mutually dependent everywhere, and no separation of these two actions in any part of the body actually takes place, although, for clearness, I have considered them separately. The progress of all accurate knowledge of the actions of medicines depends on exact chemical and physical experiments; and by the perfection of these alone will the practice of

medicine lose its doubts and difficulties, its disagreements and deceptions, and become esteemed by all as the art that can confer the highest benefit upon mankind.

### *On a Magnesium Lamp.* *By* H. Larkin.

The distinguishing peculiarity of this lamp is that it burns magnesium in the form of powder, instead of riband or wire, and does not depend on clockwork or any similar extraneous motive power for its action. The stream of the metal powder is mixed with a small portion of gas and fine sand in its progress through the tube; they escape together at its mouth, where they are ignited and continue burning with a brilliant flame.

### *On the Accumulation of the Nitrogen of Manure in the Soil.* *By* J. B. Lawes, *F.R.S., F.C.S., and* J. H. Gilbert, *Ph.D., F.R.S., F.C.S.*

The authors had been engaged for many years in an investigation in the course of which they had grown wheat year after year on the same land for more than twenty years; on some portions without any manure, and on others with farmyard manure, or with various descriptions of manure. They had published the results obtained in the field during the first twenty years of the experiments *, and they had been for some time, and were still engaged in investigating the composition of the produce grown under the different conditions, and also the comparative composition of the soils of the different plots as affected by the various treatment.

The point to which they chiefly confined attention on the present occasion was the accumulation, and the loss, of the nitrogen which had been supplied in the manure and not recovered in the increase of crop. After discussing the difficulties of sampling, preparing for analysis, and analyzing soils in such manner as to yield results applicable to the purposes of their inquiry, and describing the methods they had adopted, they called attention to some of the results obtained, summaries of which were brought to view in Tables hung up in the room. The percentage, and calculated acreage, amounts of nitrogen existing in such condition as to be determinable by burning with soda-lime were given for the soil of the first, of the second, and of the third nine inches, of eleven differently-manured plots, showing the amounts, therefore, to the depth of 27 inches in all.

The accumulation of nitrogen from the residue of manuring was found to be, in some cases, very considerable; but even with equal amounts supplied, it varied, both in total amount and in distribution, according to circumstances; the depth to which the unused supply had penetrated being apparently influenced by the character and amount of the associated manurial constituents. The general result was, that, although a considerable amount of the nitrogen supplied in manure which had not been recovered as increase of crop was shown to remain in the soil, still a larger amount was as yet unaccounted for. Initiative results indicated that some existed as nitric acid in the soil, but it was believed that the amount so existing would prove to be but small. In fact, it was concluded that a considerably larger proportion would remain entirely unaccounted for within the soil to the depth under examination than was there traceable, and the probability was, that at any rate some of this had passed off into the drains, and some into the lower strata of the soil. Finally, it was shown, by reference to field results, that there was not more than one or two bushels of increase in the wheat crop per acre per annum, due to the large accumulated residue of nitrogen in the soil, notwithstanding its amount was many times greater than that which would yield an increase of twenty bushels or more, if applied afresh to soil otherwise in the same condition. On the other hand, it was shown that the effect of an accumulated residue of certain mineral constituents was not only very considerable in degree, but very lasting.

* "Report of Experiments on the Growth of Wheat for Twenty Years in succession on the same Land," Journ. Roy. Ag. Soc. Eng. vol. xxv. pts. 1 & 2.

*On the Sources of the Fat of the Animal Body.* *By* J. B. LAWES, *F.R.S.*, *F.C.S.*, *and* J. H. GILBERT, *Ph.D.*, *F.R.S.*, *F.C.S.**

In 1842, Baron Liebig had concluded that the fat of Herbivora must be derived in great part from the carbo-hydrates of their food, but that it might also be produced from nitrogenous compounds. MM. Dumas and Boussingault at first called in question this view; but subsequently the experiments of Dumas and Milne-Edwards with bees, of Persoz with geese, of Boussingault with pigs and ducks, and of the authors with pigs, had been held to be quite confirmatory of Liebig's view; at any rate so far as the formation of fat from the carbo-hydrates was concerned. In 1864, however, at the Bath Meeting of the British Association, Dr. Hayden, of Dublin, read a paper before the Physiological Section, in which, basing his conclusions upon certain physiological considerations of a purely qualitative kind, he expressed doubt on the point. In August 1865, again, at a meeting of the Congress of Agricultural Chemists, held at Munich, Professor Voit, from the results of experiments with dogs fed on flesh, maintained that fat must have been produced from the nitrogenous constituents of the food, and that these were probably the chief, if not the only source, of the fat even of Herbivora. In the course of the discussion which followed, Baron Liebig disputed this conclusion; and his son, Hermann von Liebig, has since written a paper on the subject, in which, illustrating his views by reference to experiments with cows, he admits the probability that fat may be formed from nitrogenous substance, but nevertheless concludes that this is neither the only nor even the chief source of fat, in the ordinary feeding of Herbivora.

The authors agreed with the conclusions of these latter authorities. The data cited by Hermann von Liebig did not, however, afford conclusive evidence on the point; and they considered that the results of experiments with cows were, in several respects, less appropriate for the purposes of the inquiry than those with some other animals. They showed, illustrating the various points by reference to experiments of their own, that, compared with either cows, oxen, or sheep, the pig had a much less proportion of alimentary organs and contents, consumed food of a much higher character, produced a much larger amount of fat both in relation to a given weight of animal within a given time and to the amount of food consumed, voided a much less proportion of the solid matter of its food in its solid and liquid excretions, and, finally, its increase contained a larger proportion of fat. For these reasons results obtained with pigs must be much more conclusive as to the sources in the food of the fat which they yield than those with either cows, oxen, or sheep.

Tables were exhibited showing the results which had been obtained by the authors in numerous experiments with pigs; and from these the following main conclusions were drawn:—

1. That certainly a large proportion of the fat of the Herbivora fattened for human food must be derived from other substances than fatty matter in the food.
2. That when fattening animals are fed upon their most appropriate food, much of their stored-up fat must be produced from the carbo-hydrates it supplies.
3. That nitrogenous substance may also serve as a source of fat, more especially when it is in excess, and the supply of available non-nitrogenous constituents is relatively defective.

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*On the Poisonous Nature of Crude Paraffin Oil, and the Products of its Rectification upon Fish.* *By* STEVENSON MACADAM, *Ph.D.*, *F.R.S.E.*, *F.C.S.*, *Lecturer on Chemistry, Surgeons' Hall, Edinburgh.*

The great extension of paraffin oil-works, both crude and refined, during the last few years, has led to attention being directed to the nature of the discharges which emanate from such, more especially to those matters which find their way into rivers which form the natural drainage of the district. The deleterious nature of these discharges has manifested itself already in the total destruction of all fish in more than one of our Scottish streams, and to the impregnation of the water with paraffin oil, and the products of its rectification, to such an extent as to impart the characteristic taste and odour of paraffin to the water, and render it unsuitable for domestic purposes.

* For fuller report, see the Philosophical Magazine for December 1866.

nature of these liquids and mixtures upon the life of fish, and the general results of the inquiry I purpose to lay before the Section.

The discharges from the paraffin oil-works are of the following nature :—

1. Crude petroleum and shale-oil escaping from the crude oil-casks, either when full or when empty, when the drainings leak away into the surrounding soil and thence to the drains.

2. The condensing water from the worms of the crude and refining stills, which often passes away impregnated with paraffin oil.

3. The spent acid liquor which has been used in acting upon the crude petroleum or shale-oil.

4. The spent alkaline liquid or soda which has been employed in acting upon the oil which has been previously treated with acid.

Besides these there is the accidental overflow of the retorts, both during the first redistillation of the crude oil, and subsequently in the distillation of the refined oil, and which can hardly be altogether provided against.

The drainings from the oil-casks, when the latter have been emptied and are exposed to the sun, are considerable when a number of casks are stored together, and the oil which percolates through the soil is liable not only to ooze through the ground, but when rain falls, the oil floats thereupon, and is thus carried into the ordinary drains. Any material damage to rivers, however, from this cause may be lessened by providing proper surface drains, which carry all the oily water to traps where it settles, and the oil may be removed from the surface whilst the water is run off underneath. The condensing water from the stills is liable to be impregnated with paraffin oil from the leakage of the pipes, which is greater when the pipes are of cast iron than when they are constructed of malleable iron. Of course any excessive leakage is quickly arrested, but there is generally that taint communicated to the water which, independent of the lesser proportion of oxygen dissolved in the water as compared with ordinary river-water, renders the water more or less deleterious to the health of fish.

The spent acid liquor and the spent soda-liquor, however, are the most serious discharges which, either regularly or occasionally, escape from paraffin oil-works, and their influence upon the health and life of fish are much more decided than the paraffin oil itself.

The spent acid liquor consists of the sulphuric acid which has been added to the crude oil, accompanied by tar products, including picoline and other basic oils, and to which the acid liquor no doubt owes part of its poisonous properties. Whilst now the material in question is to some extent utilized by separating the tar, and either mixing it with spent oak bark, or sawdust, and using it as a fuel, or by distilling it into pitch, yet occasionally the acid liquor is discharged into a neighbouring stream. It is a black tarry liquid of the consistence of molasses, with a somewhat sulphureous odour, and a very small quantity added to water confers poisonous properties upon the latter.

In one example I found the spent acid liquor, which was collected somewhat diluted with water, to possess the following powerful effects upon fish :—

1. When the liquor was taken by itself and fish immersed therein, they were dead in five minutes.

2. When the liquor was diluted with three times its volume of good stream water and fish introduced into the mixture, they were killed in ten minutes.

3. With one of the liquor and twenty of water, the fish died in fifteen minutes.

4. One of the liquor and 100 of water, killed the fish in fifteen to twenty minutes.

5. One of the liquor and 1000 of water was poisonous to the fish in two hours, whilst

6. In one of the liquor to 10,000 of water, the fish were not killed by their immersion in the mixed liquor for twenty-four hours, but were apparently sick and prostrate.

The spent soda-liquor which has been employed in treating the oil which had been previously acted upon by acid is necessarily decidedly alkaline and caustic in

its nature. It has extracted from the oil and retains in solution more or less carbolic acid and its homologues, and the poisonous nature of the spent soda-liquor is doubtless materially augmented by the presence of these acids.

One sample of this soda-liquor which was flowing from a paraffin oil-work, and which contained extra water, proved destructive to fish in ten minutes; diluted with three parts of water, it killed fish in twenty minutes; with twenty of water, the fish were dead in twenty-five minutes; with 100 of water, the fish were killed in thirty minutes; diluted with 1000 of water, the soda-water was destructive to fish in twenty hours; whilst in 10,000 of water the fish were not killed but were apparently slightly sick. Experiments were made with crude shale-oil and the refined oils obtained therefrom, and with crude Pennsylvanian petroleum, and the refined oils extracted from it. The crude shale-oil was destructive to fish when taken in the proportion of 1 of the oil to 1000 of water—the crude oil being more energetic in its action than any of the others, then in succession the lubricating oil, the burning oil, and the lighter spirit.

The Pennsylvanian petroleum was not so powerful in its poisonous properties as the shale-oil employed in the experiments. The crude shale-oil, in the proportion of 1 to 1000 of water, was poisonous to fish in twelve hours; whilst the crude Pennsylvanian oil in the same proportion did not kill the fish for twenty-four hours. The refined oils acted in a corresponding manner on fish. Thus the refined shale-oil, in the proportion of 1 to 1000 of water, killed the fish in twenty-four hours; whilst the refined Pennsylvanian oil did not prove destructive for two days.

The importance of this subject will probably soon be greater than what it is at present, as the manufacture of crude paraffin oil in conjunction with gas has already been introduced into one of our gas-works in Scotland.

The coal used is the Newbattle gas or Cannel coal, which yields when distilled in ordinary gas-retorts, at a bright cherry-red heat, about 11,000 cubic feet of gas, with an illuminating or photogenic power of thirty-four standard sperm candles for every five cubic feet of the gas burned during every hour. When distilled, however, at a low or black-red heat in larger retorts, as carried on in ordinary paraffin oil-works, the coal yields only 3000 to 3500 cubic feet of illuminating gas, with the photogenic power of thirty candles for every five cubic feet burned during the hour, so that two-thirds of the total quantity of gas capable of being yielded by the coal is sacrificed; but in place thereof there are obtained about 60 gallons of crude paraffin oil with a specific gravity of 900 to 905. The gas-works in question are virtually crude paraffin oil-works in which the gas is utilized; and as the change in the mode of working the coal appears to be profitable, there is every reason to consider it likely that other gas-works will follow the example, and become virtually crude paraffin oil-works with refineries attached thereto.

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*On an Extraordinary Iron Stone.* *By* Dr. T. L. PHIPSON, *F.C.S. &c.*

The author alludes in this paper to a journey which he made during the year 1865 in the principality of Waldeck (Germany), and gives an account of the mining district which he visited there. About twelve English miles from the mineral springs of Wildungen, in the region where the schists are upheaved by greenstone, containing lodes of copper ore, lead ore, and barytine, with some zinc blende, he met with a very remarkable ironstone which is distinct from the fine red hematite that abounds in these districts, by the presence of a considerable amount of magnetic oxide of iron, some specimens yielding as much as 23 per cent., and when smelted give about 59 per cent. of iron of exceedingly fine quality. This mineral occurs in a quartz lode, is crystallized in the rhombic system, and as brilliant as steel. It gives a dark purple powder. The red hematites of the same district all contain a little magnetic oxide, varying from 2 to 4 per cent. and even more.

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*On the Origin of Muscular Force in Animals.*
*By* Dr. LYON PLAYFAIR, *C.B., LL.D., F.R.S.L. & E.*

The author reviewed the recent experiments of Fick and Wislicenus on this subject. These physiologists ascended the Faulhorn, after having subsisted for thirty-one hours on cake made of starch fried in fat, and they found that they

ascended the height of 2000 metres, with an evacuation of urea which, converted into muscular substance, did not represent more than half the actual energy expended in the ascent. The author pointed out as the main objections to this experiment (1) that the period of production of urea is not necessarily the period of its elimination; (2) that when starch and fat are used as food alone, the nitrogen of the alvine dejections, usually only one-twelfth that in the urinary secretions, augments so much as sometimes to be equal in amount to the latter. With respect to the first objection, E. Smith has shown that lowering of the barometer and thermometer retards the evacuation of urea, and these conditions were obviously present at the top of a high mountain. The amount of urea passed for twelve hours before the ascent was 46 grammes; but it was only 38 grammes in the six hours of the ascent and six hours after it; while it fell to 32 grammes in the subsequent twelve hours, although a hearty meal had been taken. The result was not easily explicable on Liebig's views, that muscular force is produced by muscular waste; but it was equally difficult to explain on the view that the urea is the mere representation of the waste of muscle due to the friction of the machine, whose natural fuel is non-nitrogenous food; for the experiments show that when the friction of the machine was largely increased by the work performed, the amount of urea actually diminished, instead of increasing proportionally to the work.

The author then entered largely into the proofs offered by experience in feeding man and animals, that albuminous diet must be offered in proportion to the work demanded. He showed that there was sufficient potential energy present in the ordinary supply of albumen to men to account for the work performed. But he did not deny that non-nitrogenous diet might, in the absence of such albuminous supply, be temporarily used for the production of muscular force. Such vicarious action is common in the body. But this admission did not interfere with the view that the normal food and fuel of muscles consists of albuminous bodies, which must constantly be supplied to produce sustained effort, and to prevent corporeal deterioration.

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*On a New Process in the Manufacture of White Lead.* *By* PETER SPENCE.

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*On some Phenomena connected with the Melting and Solidifying of Wax.* *By* C. TOMLINSON, *F.C.S.*

When melted bees-wax containing a small portion of a very fine powder, such as that of plumbago, is poured into a shallow tinned-iron tray and allowed to cool, the wax breaks up into a number of hexagonal figures more or less regular, the boundaries being marked by the plumbago. The lines of the hexagons are formed by the mutual pressure of rings of plumbago powder thrown off from cylindrical or polygonal centres of the wax in cooling. Even in deep vessels of melted stearine or grease, containing particles capable of floating about in it, and of being carried to and fro by currents, an irregular network is formed by the particles arranging themselves on the surface in lines. There appears to be on the surface a movement of the grease from the centre to the sides of each of these polygonal figures. The figure varies with the material, and may be shown during the cooling. It may be seen on castor-oil and other fatty bodies; but not on spermaceti or crystalline fatty bodies. The figures are produced by a kind of local convection; that is, convective currents rise and sink in various parts of the mass, so that from many points at the bottom of the vessel rising currents are set up, and as the surface of the oil cools by exposure to the air, these cooler portions sink from various points of the surface, so that, instead of one central rising current, and one circumferential sinking current as in ordinary cooling, many small rising and sinking currents are established. Hence the surface becomes divided into many spaces, in the centre of each of which a current of warm oil is rising and around the circumference of which the cooler oil is sinking. Each of these systems tends to form a cylinder, with a rising central and a sinking circumferential current, and the contact of the boundaries of such cylinders produces a series of polygon-shaped systems. If the surface be very still, and there be no tendency in the oil to crystallize as it cools,

nearly perfect hexagons are formed, and as the circumference of each hexagonal system is cooler than its centre, the floating particles are first arrested at the circumferences, and gradually accumulate there, giving an hexagonal appearance to the surface as the mass cools. In a crystalline material the tendency to assume its peculiar crystal would probably overcome these currents before the mass became cool.

The second part of the paper referred to the passage of an electric spark through melted wax, &c. The early electricians remarked that a non-conductor, when melted, became a conductor. Faraday found that when such substances were fused and tested by their power to transmit a voltaic current, in no case did the current pass, unless accompanied by polarization of particles and decomposition. The same seems to be true for frictional electricity. The substance to be tried was contained in a glass bulb about 2 inches across in the widest part, and about 3½ inches high, fitted with corks through which pointed brass wires were passed, or one pointed and one knobbed. On hanging such a bulb by its wire to the prime conductor of an electrical machine, connecting the lower wire with the earth, and setting the machine in action, a most vivid spark plays between the wires, striking out, as it were, from an anvil a multitude of smaller sparks, and lighting up the whole of the bulb and liquid in a remarkable manner. The smaller sparks, which apparently fill the bulb, are globules of gas, arising from the decomposition of a portion of the liquid, and illuminated by the principal discharge. When the point and bulb are far apart, the discharge is in the form of a brilliant rippled line of light, also accompanied by decomposition of the dielectric. The effects vary with different substances, and also change with the cooling of each substance. Spermaceti, cocoa-nut oil, lard, and solid paraffin are well adapted to these experiments, and also such fluids as castor-oil, balsam of copaibæ, paraffin oil, turpentine, and benzole. It was not found possible to pass a spark through melted camphor. By holding a bulb containing the solid over a spirit-lamp, the solid may be melted in a few minutes. The phenomena form good class experiments.

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### *On a Phosphatic Deposit in the Lower Green Sand of Bedfordshire.*

*By* J. F. Walker.

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### *On a Proposed Use of Fluorine in the Manufacture of Soda.*

*By* Walter Weldon.

When sulphate of sodium is treated with hydrofluoric acid, one half of the sulphate is converted into bisulphate and the other half is transformed into fluoride. Upon this fact of the reaction between sulphate of sodium and hydrofluoric acid yielding, without any destruction of sulphuric acid, a compound almost as readily caustifiable as carbonate of sodium itself, the author believed that it would prove practicable to base a manufacturing process by means of which soda should be produced, not only, if not exactly without the use, at any rate without any consumption of sulphuric acid, but actually without the consumption of any materials whatever excepting salt and coal, all the reagents employed being recovered for use over and over again continually. One method by which this object could be accomplished was described as follows. It comprises four operations, the first of which consists in the production of sulphate of sodium by double decomposition between chloride of sodium and sulphate of magnesium, having associated with it at least one atom of water, the products of this reaction being, besides sulphate of sodium, hydrochloric acid and magnesia. The second operation consists in treating two equivalents of sulphate of sodium with one equivalent of hydrofluoric acid, whereby one equivalent of fluoride of sodium, which for the most part precipitates, and one equivalent of bisulphate of sodium, which remains in solution, are formed. The third operation consists in the decomposition of the fluoride of sodium obtained in the second operation by means of the magnesia obtained as one of the results of the first operation, the products being caustic soda and fluoride of magnesium; and the fourth operation consists in the decomposition of this fluoride of magnesium by means either of the bisulphate of sodium obtained in the second operation, or of its second equivalent of sulphuric acid, separated in any conve-

nient way, with production of sulphate of magnesium, with which to repeat the first operation, and hydrofluoric acid, with which to repeat the second operation. All the reagents employed for the transformation of salt into soda by this method are thus continually reproduced, the only materials *consumed* being the salt and a small quantity of fuel. The author also described some briefer methods than the above of transforming salt into soda by way of the intermediate production of fluoride of sodium.

## GEOLOGY.

### *Address by* Professor A. C. RAMSAY, *LL.D., F.R.S., &c., President of the Section**.

SINCE I last had the honour of acting as President of the Geological Section a custom has crept in of opening the meetings of the various Sections with presidential addresses. I have, however, been called upon unexpectedly, and rather late in the day, to occupy this chair, while I was busy with a multitude of other avocations, and I have not had the time to prepare an address; nevertheless I shall endeavour to the best of my ability to say a few words upon the state of opinion upon various subjects connected with physical geology, so as, possibly, to prepare in some degree the minds of persons, who are not thoroughly conversant with all branches of the science, for topics that may, perhaps, be touched upon in some of the papers to be brought before us. The great question which underlies much that concerns geologists is whether the economy of the world as we now see it represents in kind, and partially or altogether in degree, the average economy of the world as it has existed in time past, as far as it can be traced by reference to rocks and their contents as they appear at the surface, or as deep beneath the surface as we may dare to reason upon within the limits of presumed legitimate inference.

After people had thoroughly made up their minds that the world consisted, as far as the outside of it is concerned, of two classes of rocks—igneous and aqueous—it was for a long time the fashion to attribute most of the chief disturbances which the crust of the earth has undergone to the intrusion of igneous masses. The inclined positions of strata, the contortions of the formations in mountain-chains, and the existence even of many important faults—in fact, disturbance of strata generally, were apt to be referred to direct igneous action operating from below. But a closer analysis of the rocks founded on careful surveys, not of a little area here, and a little area there, but on surveys of kingdoms and continents, has tended to disprove these old-fashioned ideas, although you may constantly see them brought up again and again in a certain class of popular works, and sometimes even in memoirs by authors who ought to be better informed than merely to repeat the notions that we find in common-place popular works on geology.

Now, if we look at those British formations in which igneous rocks are most generally developed, what do we find? Go first to North Wales, to the Lower Silurian strata, which are to a great extent intermixed with igneous rocks. There, instead of finding great masses that broke through the stratified crust of the earth and tumbled the strata into confusion, the igneous rocks consist chiefly of beds of felspathic lava and ashes of great thickness interstratified among the Lower Silurian strata, with here and there bosses of porphyry, which may sometimes represent, as I think, the underground nuclei of old volcanoes of Lower Silurian age; but the mountainous character of the country is due, not to the direct igneous action of that period heaving up the rocks. On the contrary, all the rocky masses of which the region consists, both igneous and aqueous, have been disturbed and thrown into great sweeping undulations formed of curved strata, thousands of feet thick, by those agencies, whatever they may have been, that at a later date pro-

* This address was very imperfectly taken down in shorthand, and the speaker has since corrected it, and supplied the omissions of the reporter, to the best of his ability, from memory.

duced disturbance. The igneous rocks were not that cause; for they have themselves been disturbed, together with the fossiliferous Lower Silurian rocks amid which they lie; and the mountainous character of the country, as it now presents itself, is due, not to direct volcanic action, but to the unequal hardness of igneous and aqueous masses, acted on by many denudations both ancient and modern, both marine and subaërial. These causes, aided by faults which often brought hard and soft rocks into immediate juxtaposition, have given rise to all the rugged outlines on the surface of Wales, the hard rocks more strongly resisting decay and waste, the soft ones yielding to time, the sea, and the weather, with greater ease; and thus it happens that the harder masses generally form headlands, and the summits of the mountains, though often found elsewhere; while the softer strata, wasted away by the sea and by rain and rivers, are apt to lie in the recesses of bays and in valleys and plains. This kind of argument I could equally well apply to the Carboniferous formations of Scotland, where igneous rocks are rife, and, indeed, to all those areas where igneous masses of ancient date are found intermixed with sedimentary strata*.

Again, if we go to the Alps, and look at the strata there, which are disturbed on the greatest scale; in all that part of the range that I best know, from east to west for more than 100 miles in length, I have never seen a fragment of what I can call a true igneous rock. Gneiss there is, and granite there is, which, according to old ideas—a great advance in their day—some have been apt to classify either as common igneous productions or as closely allied to them; but no basalts or greenstones, or rocks allied to these, play any important part in the structure of the country, although the strata have been disturbed in a manner of which no conception can be formed by those who have only studied such minor mountains as those of the British Isles. There, in the Alps, we find areas as large as half an English county, in which a whole series of formations has been turned upside down. But by what means were masses of strata many thousands of feet thick bent and contorted and raised into the air so as to produce existing results by affording matter for the elements to work upon? Not by igneous or other pressure and upheaval from below, for that would *stretch* instead of *crumpling* the strata in the manner we find them in great mountain-chains like the Alps, or in less disturbed groups like those of the Highlands, Wales, and Cumberland, which are only fragments of older mountain-ranges; but, perhaps, as some have supposed, because of the radiation from the earth of heat into space, producing gradually a marked shrinkage of the earth's hardened crust, which, giving way, became crumpled along lines more or less irregular, thus producing partial upheavals, though the bulk of the whole globe was diminishing. A modification of this hypothesis does not attempt to explain the positive cause of the shrinkage, but simply states, that from some unknown cause, irrespective of radiation, great areas of the earth's crust having been depressed, broad lines that lie between them have been contorted and heaved into the air in the manner already indicated. Such shrinkage and crumpling, however it was produced, when most intense and on the greatest scale, is always (where I know it) accompanied by the appearance of gneissic or other metamorphic rocks, and of granite or its allies; and it has often been the custom to attribute the disturbance of the strata in such mountain-ranges and their metamorphism into gneiss, crystalline marble, and the like, to the intrusion of granite. But my opinion has long been that, with regard to gneiss and granite, the first has been produced by processes of metamorphism which had no necessary connexion with the intrusion of granite, while granite itself is often simply the result of extreme metamorphism, having passed through and beyond the stage of imperfect crystallization, characteristic of gneiss, into that state of more perfect crystallization which marks well-developed granite. If this be so, then, so far from the intrusion of granite having produced such mountains as those I speak of, both gneiss and granite would rather seem to be results of the forces that formed the mountain-chains, I cannot tell how, but possibly connected with the heat produced by the intense contortion of such vast masses of strata, the parts of which now exposed by denudation were then deep underground. There is, however, a difficulty here

* This argument has of course no *immediate* application to existing or late Tertiary volcanic areas, such as those of Auvergne, where entire and ruined craters still exist.

perhaps insuperable, and which my knowledge does not enable me to grapple with; viz., that if the shrinkage that contorted the strata were slow, the heat resulting from it might never have attained sufficient intensity to have produced, with the aid of alkaline waters, those common metamorphic masses, known as gneiss, granite, syenite, &c., and others less commonly recognized as metamorphic, such as some of the quartz porphyries, for the heat thus generated may have escaped as fast as it was formed. But I cannot now enter on these details.

It has often been customary to speak of the Cumbrian mountains as a great dome, forces from below having heaved up the strata towards a central point, from whence the main valleys radiate as great rents produced by that upheaval. But the strata of Cumberland are not dome-shaped in the true geological sense. If it were so, the strata ought to dip from the centre. But instead of that we find Lower and Upper Silurian strata from the equivalents of the Llandeilo flags to the Ludlow beds, which though contorted, yet form an ascending series all across Cumberland from Cockermouth to Ambleside, with an average south-easterly dip. There is, indeed, nothing cone-like in the manner of their arrangement, and the igneous rocks associated with the Cumbrian strata have partaken of disturbances of the same ages as those that heaved up the Silurian rocks of Wales. Afterwards the whole series was planed across by marine denudation before the deposition of the Old Red Sandstone of the area; and then, but chiefly at later periods, the valleys were scooped out from a great tableland, an old plain of marine denudation, especially after the removal by denudation of the Carboniferous rocks which at one time probably cased and concealed the whole of the Silurian strata. In this manner the character of the mountains of the country was produced, the harder masses being apt to form the heights, craggy, yet often rounded by glacial action.

Now in disturbed districts, and in many not much disturbed, faults are more or less numerous, and they are of all ages and of varying amounts. On the Continent of Europe and in Britain, for example, from the Middle Tertiary strata downwards, somewhere or other, all the formations have been dislocated, some of the faults being of the amount of only a few inches or yards, and others of many thousands of feet. Several I know in Wales of 2000, 5000, or even 12,000 feet in amount; and as a rule it is found that the greatest faults intersect strata that have been most disturbed, while also it often happens (but not always) that the oldest strata have undergone most disturbance, because they have been more frequently affected by disturbing agents. On the north side of the Alps the Miocene rocks of the Rhigi are inverted and faulted against the older formations, and the amount of the throw must be very large, and as many Miocene species of mollusks are still living, far as it is removed from our epoch, this fault, by comparison with older ones, may almost be said to approach our own day.

Now the question arises whether the agencies that produced contortion of strata and faults, which in certain cases have resulted in the formation of great mountain-chains, have been sudden in their operation, or if the changes have been as progressive and gradual as the operation of those agents of denudation—the sea in the formation of plains of marine denudation, old and new, and the outlines of coasts; together with the work of air, rain, rivers, frost, snow, and ice, that, long continued, have produced the familiar sculpturing of hill and valley. This is a very puzzling question to geologists, and various opinions have been stated. One of these is that we now live in a world, as it were, nearly in a finished state, and which will suffer no more catastrophes; another that the world now remains in a temporary state of repose after a succession of spasmodic throws which broke up suddenly great portions of the earth's crust, and repeatedly revolutionized the world, and that such efforts may recur at later periods a long way beyond our time; or again, that the state of tranquillity we now enjoy, in which change is constant, more or less slow, and very sure, has been the order for all time, as far as geologists can trace back the history of the world in the rocks that form its crust. These are the leading opinions on the subject, and my own inclines to the last.

But in the present state of our knowledge it is impossible to reduce to a demonstration the truth of this opinion. Those who fancy the world to be in a finished state are seemingly forgetful of the fact that the old rocks were made by the same operations as those that are now forming; and those who advocate sudden violence

and wide-spread revolution have, it seems to me, nothing beyond assertion to help them, founded on that kind of wonder and awe that arises from the contemplation of crags, peaks, and the inversions of the strata of great mountain-chains, or of other and kindred phenomena; while the advocates of peaceful change have little to say beyond an appeal to observed facts, gathered from a study of rocky masses and their contents, which to them seem to point throughout to gradual and continuous changes; and these imperfectly understood phenomena have induced a half intuitive and growing belief that the laws, both physical and biological, that govern the world are quiet, progressive, and unviolent.

Proceeding now a point further, the connexion of life with the modifications which have taken place in the crust of the earth somewhat helps us in our endeavours to understand the question. As every one knows, there have been great numbers of different genera and species inhabiting the world at different geological epochs, the remains of which lie buried in the various formations; and looked at on a large scale, and over broad areas, it is evident that there has been a succession of life, each of the greater series of formations being more or less marked by its own particular fauna. This fact led to the old geological doctrine that there had been many sudden creations, by which the world was at various times peopled; that these inhabitants, after long intervals, were as suddenly destroyed; that new creations came in, and that each formation was in this way marked by its peculiar forms of life. When, however, it was found that in some formations a few, or sometimes many, of the same species were common to two or more formations, this theory of complete and sudden extinction and creation was seen to be untenable. By and by, when the geological structure of Britain began to be minutely analyzed, it was found in cases of unconformable stratification, even when the upper formation was *in time* the next *known* member of the series to that which lay below, that breaks in the succession of *marine life*, partial or total, always accompanied such unconformities in stratification. It has, indeed, been a question with some geologists whether two marine faunas, commonly recognized as belonging to two distinct and far apart geological epochs, such as the Silurian and Carboniferous, could not have been contemporaneous in past eras, or indeed even now. It is very possible that something of this kind may have been the case; but in my opinion only in a mixed and minor way between periods or formations that in a geological sense were not far apart in time. When we consider the greater formations, such as Silurian and Carboniferous, Oolitic and Cretaceous, the probabilities, as I have elsewhere argued, are almost infinitely against this assumption; for if so, an Oolitic fauna, for example, in whole or in part might both underlie and overlie Cretaceous formations. But, however we may look upon this question, it is certain that the great principle of a succession of life, showing a method of change and progress, the old disappearing, and the new coming in, and *breaks in succession of life*, as I have shown in detail elsewhere, have a close connexion with unconformability of strata and *gaps in geological time unrepresented by stratified formations* over areas of varying size, such areas being determined by those agents that produced upheaval and denudation of continents and islands.

I could follow out this view with particulars, but without now doing so, this reasoning seems to assure us that there never has been universally over the world any complete destruction of life, but that the succession of being has gone on in regular order and sequence, though for a time, or for ever, we have lost many of the records—whole chapters, whole books, in consequence of the disturbances and slow denudations which the earth's crust has undergone. This must show, therefore, that there never has been any universal catastrophe which destroyed the life of the world; especially because many of the forms are still alive that belong to comparatively old epochs; and to my mind the continuity of genera and even of broader distinctions leads to a like result. But great changes in physical geography have often taken place in times *too limited* to have involved total changes of life; for life, I believe, dies out or changes not by violence or sudden edict, but by the slow effects of time. The north of Europe and America has been more than half submerged during the last glacial epoch, and re-arisen without the disappearance of any one marine mollusk. Of the fossils of the Crag, part of an old German ocean,

have been formed, upheaved, inverted, and faulted without a total destruction either of terrestrial or of aqueous life. Putting all these things together, I feel myself almost driven to the conclusion that all these changes have been so slow and gradual, that to occupants of old time, had there been human intelligence to observe, everything would have seemed to go on in the same slow, steady, and apparently undisturbed manner in which they appear to us to go on now; and if this be true, then, instead of having recourse to unusual catastrophic action to explain what is seen to have resulted, it all resolves itself into time—to effects in fact produced by small cumulative causes, which were more than equal to all the destructive forces attributed to eruptions of igneous rocks, the production of faults, and immense contortions of strata; and the effect of all, but not the final effect, has brought about the astonishing changes which the world has so visibly undergone, resulting in the present physical geology, physical geography, and life of the surface of the earth.

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*On Intermittent discharges of Petroleum and large deposits of Bitumen in the Valley of Pescara, Italy.* *By* Prof. Ansted, *F.R.S.*

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*On a Salse or Mud Volcano on the flanks of Etna, commencing to erupt in the month of January last.* *By* Prof. Ansted, *F.R.S.*

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*An Attempt to approximate the Date of the Flint Flakes of Devon and Cornwall.* *By* C. Spence Bate, *F.R.S.*

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*On the Island of St. John in the Red Sea (the Ophiodes of Strabo).* *By* Dr. Beke.

The author gives an account of his visit to the Island of St. John, in the Red Sea, which he described as an upraised coral-reef, with a sharp volcanic peak in the centre. It afforded neither water nor vegetable productions. There was evidence along both coasts of the Red Sea that the land was uprising. The author exhibited a number of geological specimens collected on the island.

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*On the occurrence of Flint Implements in the Gravel of the Little Ouse Valley at Thetford and elsewhere.* *By* Henry Brigg, Jun.

The author in this paper described some discoveries of flint implements at five points in the valley of the Little Ouse, a river having a common origin with the Waverney at Lopham Ford, and which, after receiving the waters of the Thet and another small river, takes a north-west course, and joins the Great Ouse.

The country drained by the Little Ouse and its tributaries, is of the Upper Chalk, largely overlaid with glacial drift; and the river-valleys exhibit extensive deposits of the debris of these formations arranged terrace-like upon their sides.

From Thetford to Brandon the valley-gravels attain their greatest development, and are extensively quarried during the winter months for road-making material.

It was at Santon, in the spring of 1862, that the first flint implement was discovered, and Mr. Brigg has since recorded further discoveries at the Red Hill and White Hill, Thetford (slight eminences upon the Abbey-heath, thus called by the pitmen from the colour of the gravels), Santon Downham, and further down the river, and without the valley, at Shrub Hill, in Feltwell fen.

The discoveries at the Red and White Hill are important; the first from the large number of implements that have been found, the latter from the occurrence in the same deposit of remains of the *Elephas primigenius*, *Equus*, *Sus*, &c. The implements of the Little-Ouse gravels are mostly of the spearhead form, with the usual variety of finish and staining. Many of them show traces of wear from use, while others have suffered much attrition and water-wear.

The paper concludes by contrasting the flint tools of Thetford with those found in other parts of England, and comments upon their probable use and adaptation.

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*On the Correlation of the Lower Lias at Barrow-on-Soar, Leicestershire, with the same Strata in Warwick-, Worcester-, and Gloucester-shires, and on the Occurrences of the Remains of Insects at Barrow. By the* Rev. P. B. Brodie, *M.A., F.G.S.*

The author first described two sections of the "Insect and Saurian" beds at Barrow-on-Soar, not previously noticed. These were compared with other adjacent sections, and the variations in the strata duly noted. The Insect beds were shown to occupy their normal position; but the thickness of the latter was not so great in Leicestershire as in Warwickshire. Hence a considerable thinning out of the Lower Lias in this direction was inferred. The Insect-bed were believed to extend into Nottinghamshire, and they have been also observed near Cave in Yorkshire. It remains to be proved whether the "Rhætic series" is present beneath in Leicestershire and Nottinghamshire as in Warwickshire. It has been lately detected near Gainsborough, in Lincolnshire. A general comparison was then given of the lower Lias in the county of Leicester with the same series in Warwick, Worcester and Gloster. The insect limestones were shown to be of much economical value in making hydraulic lime and for other purposes. Several faults on a small scale were noticed both at Barrow and at Wilmcote, in Warwickshire, in this zone. The characteristic fossils were pointed out; and it appeared that saurians and fish were abundant, more so at Barrow than Wilmcote; and the remains of insects were now for the first time indicated there, though they had been long since discovered in the same division in Yorkshire. It was argued in conclusion, that these lower Liassic limestones have a very extensive horizontal range, and are characterized by the remains of insects throughout, which really distinguish them far better than the Saurians, which have a much wider vertical range.

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*On the Drift Deposit on the Weaver Hills. By* E. Brown.

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*On the Occurrence of the Rhætic Beds, near Gainsborough and the surrounding Strata. By* F. M. Burton.

Gainsborough is situate at the foot of a moderately steep escarpment of the Keuper or uppermost division of the Triassic system.

This escarpment consists of the usual beds of the series, yellow and blue marls alternating with brown and grey sandstones and beds of gypsum; the latter presenting both the granular and fibrous varieties. Owing to the operations of the Great Northern Railway Company, who are lowering the gradients of their line to Lincoln, a fine section of Rhætic beds has been exposed at Lea, about two miles from Gainsborough, where the lowest bed of the series, containing *Avicula contorta*, bones, and coprolites, is seen resting unconformably, though with parallel stratification, on the blue marls of the Keuper. This is followed by a band of black shale nearly unfossiliferous, above which comes the bone-bed, a narrow band full of worn bones, teeth, scales, and coprolites, imbedded in a cement of pyrites. This is followed again by a number of other beds of shale, sand, and limestone, of variable thickness and degrees of hardness, the highest at present exposed, a band of black shale about two feet thick, containing large Septarian nodules.

The whole series is highly pyritous, and contains *Avicula contorta*, *Pullastra arenicola*, with teeth of *Hybodus*, *Acrodus*, *Sargodon*, *Termatosaurus*, and other Rhætic fossils in abundance.

The Rhætic beds are capped by a stratum of drift which covers the surrounding country, and through which the cutting passes to Marton Station, about three miles from Lea, where a fine and very fossiliferous section of lower lias is laid bare.

Amongst the specimens found there are *Septastræa Fromenteli*, *Montlivaltia Hameii*, *Pleurotomaria Anglica*, *Turbo elegans*, *Lima Hettangiensis*, several species of Ammonites, and others.

*On a Curious Lode or Mineral Vein at New Rosewarne Mine, Gwinear, Cornwall.* *By* Dr. C. Le Neve Foster, *F.G.S.*

The author observed that it was chiefly remarkable as being a brecciated lode, containing rounded pebbles. The lode or vein ran east and west, and dipped south, the average dip being about 85 degrees. The surrounding rock was the ordinary "killas," or a hard shale, for which the name of clay-slate was not appropriate. The lode, which had an average width of about 8 feet, contained on the north side mainly tin, and on the south copper ore. The "tinny," or stanniferous part, some 6 feet wide, consisted of fragments of killas, elvan, and killas—breccia, cemented mainly by quartz, tin-stone, mispickel, and chlorite. The fragments were mostly angular, but some of the pieces of killas and elvan were rounded—in many cases sufficiently so to be called true pebbles. The whole history of the formation of the lode described by the author implied an enormous lapse of time.

*On the Discovery of Ancient Trees below the surface of the Land at the Western Dock now under construction at Hull.* *By* Dr. F. M. Foster, Hull. Read by James Oldham, *C.E.*

The space intended for the west dock, in Hull, has been inclosed from the Humber on three sides by a coffer-dam. In the cuttings at the east end, the upper stratum is noticed to be silt deposited from the turbid waters of the Humber, locally known as "mud," and immediately under the silt, the trunks, roots, and branches of oak-trees, together with a peat soil of 2 feet in thickness, beneath that a strong clay soil, and under this (so far as is uncovered) an extensive bed of blue sand, containing the freshwater shells *Lymnæa*, *Planorbis*, &c.

At a depth of 40 feet below the level of the adjoining land, trees (chiefly oak) are found in all positions; those which are upright and still *in situ* having been broken off within 3 feet of the roots. One oak-tree, of noble dimensions, is perfectly straight, its trunk being 45 feet long, and in the thickest part measuring 12½ feet in circumference; it is tolerably sound, but blackened in colour. This tree lies nearly north and south, but others, which have also fallen, are to be met with in every direction.

In a hole caused by the decay of a branch, was found a quantity of hazel-nuts, possably the winter store of some provident squirrel; the shells, though black, were quite perfect.

The undulating state of the original surface may be seen by the silt above being of a lighter colour than the lower stratum. It is evident, from the position of the roots, that the ground on the north or land side, on which the trees grew, has been higher than the south or river side, thus indicating the side of a valley before the existence of the estuary of the Humber, and probably of the North Sea.

The trees cannot be less than 3000 years old; and would require at least 300 years to attain the dimensions given. In a boring made the chalk has been found at the depth of 110 feet below the surface of the sea.

*On the Anglo-Belgian Basin of the Forest-bed of Norfolk and Suffolk, and the Union of England with the Continent during the Glacial Period.* *By the* Rev. J. Gunn.

A question of the greatest importance had been raised by Mr. Godwin-Austen with reference to the extension of the Belgian coal-measures to this country. It was evident that in the mesozoic period, the continuous ranges of chalk in Belgium, France, and England, formed a basin, in which tertiaries were deposited. The author, after researches carried on for upwards of thirty years, had come to the conclusion that the forest-bed was the estuarine deposit of some great river or rivers flowing westward, closed on the south by a ridge of chalk-hills, and open to the sea on the north; and that such ancient river or rivers were now represented

by the several rivers flowing into the German Ocean between the mouths of the Scheldt and the Rhine. Thus there might be said to be on the English coast the remains of an estuary without a river, and on the Belgian side of a river or rivers without an estuary. The author followed up a description of the deposits by a remark that he strongly suspected the disruption of this country from the Continent took place at a more recent period than was assigned to it by geologists generally. His impression was that the forest-bed and the crag-series which preceded it could only be studied to advantage in connexion with and as part of the corresponding beds of the Continent.

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*On the Sinking of Annesley Colliery.* *By* EDWARD HEDLEY.

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*On the Miocene Flora of North Greenland* *By* Professor OSWALD HEER. *Translated by* ROBERT H. SCOTT.

The Royal Dublin Society is in possession of a rich collection of fossil plants, which have been brought from the Arctic Regions by Capt. Sir F. Leopold M'Clintock and Capt. Philip H. Colomb, at various times, and have been presented by these gentlemen to the museum of the Society. I am indebted to the kindness of Mr. Robert H. Scott, Honorary Secretary of the Royal Geological Society of Ireland, for a sight of these specimens, as the Royal Dublin Society has been induced to entrust the whole collection to me for examination. Before I received these, Dr. J. D. Hooker had entrusted to me specimens which had been presented to the Museum at Kew by Dr. Lyall and Dr. Walker. In this latter collection I discovered seven determinable species, which are also to be found among the specimens of the Dublin collection. In this I find sixty-three recognizable species. If we add to this the additional species mentioned by Brongniart and Vaupel, we obtain a total of sixty-six species.

All the specimens of the Dublin and Kew collections come from Atanekerdluk, as do also the specimens which Capt. E. A. Inglefield brought home, of which he deposited a portion in the Museum of the Geological Survey, and retained a portion in his own hands. The former have been kindly sent to me by Sir Roderick Murchison, while I have obtained the latter through the goodness of their owner.

Atanekerdluk lies on the Waigat, opposite Disco, in lat. 70°. A steep hill rises on the coast to a height of 1080 feet, and at this level the fossil plants are found. Large quantities of wood in a fossilized or carbonized condition lie about. Capt. Inglefield observed one trunk thicker than a man's body standing upright. The leaves, however, are the most important portion of the deposit. The rock in which they are found is a sparry iron ore, which turns reddish brown on exposure to the weather. In this rock the leaves are found, in places packed closely together, and many of them are in a very perfect condition. They give us a most valuable insight into the nature of the vegetation which formed this primæval forest.

The catalogue which I append to this paper will give a general idea of the flora of this forest of Atanekerdluk; but before we proceed to discuss it, I must make a few remarks.

(1) *The fossilized plants of Atanekerdluk cannot have been drifted from any great distance. They must have grown up on the spot where they are found.* This is proved—

(*a*) By the fact that Capt. Inglefield and Dr. Rink observed trunks of trees standing upright.

(*b*) By the great abundance of the leaves, and the perfect state of preservation in which they are found. Timber, hard fruits, and seeds, may often be carried to a great distance by ocean currents, but leaves always fall to pieces on such a long journey, and they are the more liable to suffer from wear and tear the larger they are. We find in Greenland very large leaves, many of which are perfect up to the very edge. It is, however, difficult to work them out from a stone which splits very irregularly; and consequently we can hardly exhibit the entire leaves in a perfect condition.

(*c*) By the fact that we find in the stone both fruits and seeds of the trees whose

leaves are also found there. Thus, of *Sequoia Langsdorffii* we see not only the twigs covered with leaves, but also cones and seeds, and even a male blossom cathin (kätzchen)—of *Populus*, *Corylus*, *Ostrya*, *Paliurus*, and *Prunus*, there are leaves and some remains of fruit, which could not be the case if the specimens had drifted from a great distance.

(*d*) By our finding remains of insects with the leaves. There is the elytron of a small beetle, and the wing of a good-sized wood-bug (probably belonging to the family of the *Pentatomidæ*).

(2) *The Flora of Atanekerdluk is Miocene.* Of the sixty-six species of North Greenland, eighteen occur in the Miocene deposits of Central Europe. Nine of these are very widely distributed both as to time and space, viz., *Sequoia Langsdorffii*, *Taxodium dubium*, *Phragmites Oeningensis*, *Quercus Drymeia*, *Planera Ungeri*, *Diospyros brachysepala*, *Andromeda protogœa*, *Rhamnus Eridani*, and *Juglans acuminata*. These are found both in the upper and lower Molasse, while some species, viz., *Sequoia Couttsiæ*, *Osmunda Heerii*, *Corylus Macquarrii*, and *Populus Zaddachi*, have not as yet been noticed in the upper Molasse. From these facts it seems probable that the fossil forest of Atanekerdluk flourished in that high northern latitude at the lower Miocene epoch.

(3) *The Flora of North Greenland is very rich in species.* This is evident from the great variety of plants which the specimens exhibit. Although the amount of material obtained from Atanekerdluk is of small extent compared with that which has come from the Swiss localities, yet many of the slabs contain four or five species, and in one instance even eleven. Atanekerdluk has been only twice visited, so that we can only consider that we have got a glimpse of the treasures buried there, and which await a more careful search. At Disco and Hare Island there are extensive beds of brown coal, in whose neighbourhood we may fairly expect to find fossil plants. In fact, Professor Göppert mentions three species from Kook (?) in lat. 70° N., *Pecopteris borealis*, *Sequoia Langsdorffii*, and *Zamites Arcticus*, which, strange to say, he has described (in his Jahrbuch für Mineralogie, 1866, p. 134).

(4) *The Flora of Atenekerdluk proves, without a doubt, that North Greenland, in the Miocene Epoch, had a climate much warmer than its present one.* The difference must be at least 30° F.

Professor Heer discusses at considerable length this proposition. He says that the evidence from Greenland gives a final answer to those who objected to the conclusions as to the Miocene climate of Europe drawn by him on a former occasion. It is quite impossible that the trees found at Atanekerdluk could ever have flourished there if the temperature were not far higher than it is at present. This is clear first from many of the species, of which we find the nearest living representatives 10° or even 20° of latitude to the south of the locality in question. Some of the species are quite peculiar, and their relationship to other forms is as yet in doubt. Of these the most important are a *Daphnogene* (D. Kanii), the genus *M'Clintockia*, and a *Zamites*. The Daphnogene had large thick leathery leaves, and was probably evergreen.

*M'Clintockia*, a new genus, comprises certain specimens belonging, perhaps, to the family of the Proteaceæ. The *Zamites* is also new. Inasmuch as we know no existing analogues for these plants, we cannot draw accurate conclusions as to the climatal conditions in which they flourished. It is, however, quite certain that they never could have borne a low temperature.

If, now, we look at those species which we may consider as possessing living representatives, we shall find that, on an average, the highest limit attainable by them, even under artificial culture, lies at least 12° to the southward. This, however, does not give a fair view of the circumstances of the case. The trees at Atanekerdluk were not all at the extreme northern limit of their growth. This may have been the case with some of the species; others, however, extended much further north; for in the Miocene flora of Spitzbergen, lat. 78° N., we find the beech, plane, hazelnut, and some other species identical with those from Greenland. For the opportunity of examining these specimens, I am indebted to Professor Nordenskiold. At the present time the firs and poplars reach to a latitude 15° above the artificial limit of the plane,

and 10° above that of the beech. Accordingly we may conclude that the firs and poplars which we meet at Atanekerdluk and at Bell Sound, Spitzbergen, must have reached up to the north pole, in so far forth as there was land there in the tertiary period. The hills of fossilized wood found by M'Clure and his companions in Banks Land (lat. 74° 27' N.), are therefore discoveries which should not astonish us; they only confirm the evidence as to the original vegetation of the polar regions which we have derived from other sources. The Professor then proceeds to say that the whole course of reasoning which led him to the conclusion that the miocene temperature of Greenland was 30° F. higher than its present one, was too long to be included in a paper like the present one; it would be fully developed in his work 'On the Fossil Flora of the Polar Regions,' which will contain descriptions and plates of the plants discovered in North Greenland, Melville Island, Banks Land, Mackenzie River, Iceland, and Spitzbergen, and which he hopes to publish at an early date.

He then selects *Sequoia Langsdorffii*, the most abundant of the trees at Atanekerdluk, and proceeds to investigate the conclusions as to climate deducible from the fact of its existence in Greenland. *Sequoia sempervirens* Lamb. (Red-wood) is its present representative, and resembles it so closely that we may consider *S. sempervirens* to be the direct descendant of *S. Langsdorffii*. This tree is cultivated in most of the botanical gardens of Europe, and its extreme northern limit may be placed at lat. 59° N. For its existence it requires a summer temperature of 60° F. Its fruit requires a temperature of 65° F. for ripening. The winter temperature must not fall below 31° F., and that of the whole year must be at least 50° F. Accordingly we may consider the isothermal of 50° as its northern limit. This we may then take as the northern temperature of the *Sequoia Langsdorffii*, and 50° F. as the absolute minimum of temperature under which the vegetation of Atanekerdluk could have existed there.

The present annual temperature of the locality is about 20° F. Dove gives the normal temperature of the latitude (70° N.) at 16° F. Thus Greenland has too high a temperature; but if we come further to the eastward we meet with a temperature of 33° F. at Altenfiord. Even this extreme variation from the normal conditions of climate is 17° F. lower than that which we are obliged to assume as having prevailed during the Miocene period.

The author states that the results obtained confirm his conclusions as to the climate of Central Europe at the same epoch (conf. *Heer, Recherches sur le Climat et la Végétation du pays Tertiaire*, p. 193), and shows at some length how entirely insufficient the views of Sartorius von Waltershausen are to explain the facts of the case.

Herr Sartorius would account for the former high temperature of certain localities by supposing the existence of an insular climate in each case. Such suppositions would be quite inadequate to account for such extreme differences of climate as the evidence now under consideration proves to have existed.

Professor Heer concludes his paper as follows:—

I think these facts are convincing, and the more so as they are not insulated, but confirmed by the evidence derivable from the Miocene Flora of Iceland, Spitzbergen, and Northern Canada. These conclusions, too, are only links in the grand chain of evidence obtained from the examination of the Miocene Flora of the whole of Europe. They prove to us that we could not by any re-arrangement of the relative positions of land and water produce for the northern hemisphere a climate which would explain the phenomena in a satisfactory manner. We must only admit that we are face to face with a problem, whose solution in all probability must be attempted and, we doubt not, completed by the astronomer.

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### *The Geological Distribution of Petroleum in North America.*
### *By* Prof. C. H. Hitchcock, *M.A., of New York City.*

During the past five years the United States of America have produced more than three hundred millions of gallons of petroleum. The average daily yield for the present year (1866) has been at least 12,000 barrels. The business of collecting, transporting, and refining it employs as many hands as either the coal- or iron-trade.

1. Petroleum sometimes occurs in *synclinal basins*, like the subterranean streams of water penetrated by Artesian bore-holes. This is the case in Western Pennsylvania, the most prolific of all the "oil-regions." It is found beneath each of three sandstones, or sets of impervious strata, designated by the workmen as the "first," "second," and "third." In the small-yield wells the oil may constitute the drainage of an inconsiderable thickness of saturated layers. The aid of pumps is often required to bring the fluid to the surface.

2. Petroleum may occur in *cavities and fissures in the strata*, either upon synclinal basins or anticlinal slopes. The existence of a cavity is inferred from the prodigious amount of fluid spouting out of the ground, as of the Grant Well at Pitt Hole, which at the time of my visit was producing 1800 barrels of petroleum every day. Many of these wells discharge their products intermittently. Besides petroleum, brine and gas are commonly, perhaps universally, discharged from the orifice; and we may suppose that, before the tapping of the cavity, they were arranged according to their respective gravities, the gas uppermost and the brine at the bottom. The varying phenomena of discharge may be explained by supposing different parts of the cavity to have been reached by the boring-rod in the several instances. When a cavity is large, two or more bore-holes may penetrate it, as was the case with the celebrated Phillips and Woodford Wells. Generally the wells of one neighbourhood seem to have some connection with one another; for if old and unproductive holes are not closed, the discharge from new and promising wells is impeded. Abandoned holes should always be plugged up, partly for the benefit of new enterprises, and partly because it has been discovered that by rest they will again become productive. The oleiferous reservoirs may be irregular cavities, vertical, horizontal, or inclined fissures, an enlargement of natural joints, &c. Explorers look for regions where the strata have been much folded and broken, promising that the dislocations may produce cavities in which fluids will accumulate.

3. Petroleum may occur along *lines of faults*. Examples of this nature are in Western Virginia, Southern Kentucky, and elsewhere.

4. Petroleum may exist *in great quantities beneath anticlinal arches*. A fault may change into an anticlinal along the strike. Examples of this nature are in Albert Co., N. B., Gaspè, C. E., and in Canada West. The roof acts as an impervious cover to confine the fluids until the drill of the workman appears for their liberation.

These facts show us where to expect petroleum in considerable amount. If we search in that area where the oil-layer comes to the surface, or its distribution is represented by the colours of a geological map, we shall find only shallow and small-producing wells. Nevertheless these may be more permanent than the deeper ones, and may be worked profitably from generation to generation, where labour is inexpensive. The great wells involve three essentials; first, plenty of bituminous matter in the petroleum formation, from which an abundant supply may be drawn; second, cavities and crevices in the strata; third, an impervious cover, like the roof of an anticlinal, to have prevented the escape of the fluid in past ages. The best "surface-indications" generally guide to shallow wells. The best reservoirs have been found at considerable depths.

5. There are no less than fourteen different formations in North America (not including the West Indies) from which petroleum has been obtained, generally in productive amount.

(*a*). Pliocene Tertiary of California. This has been known for a century.

(*b*). In Colorado and Utah, near lignite beds of Cretaceous age. Not yet explored.

(*c*). In small amount in the Trias of Connecticut and North Carolina.

(*d*). Near the top of the Carboniferous rocks in W. Va., including many of the best producing wells in the state.

(*e*). Shallow wells near Wheeling, W. Va., and Athens, O., not far from the Pittsburg coal.

(*f*). 475 feet lower, near the Pomeroy coal-bed.

(*g*). At the base of the coal-measures in conglomerate or millstone grit.

(*h*). Small wells in the Archimedes limestone (Lower Carboniferous) of Kentucky.

(*i*). Chemung and Portage groups (Upper Devonian) in at least three different levels; in W. Penn. and N. Ohio. A careful study of the distribution of the producing wells upon Oil Creek has satisfied me that they are arranged in four groups, with scarcely any intermediate stragglers. These centres are at Titusville, Petroleum, Cherry Run and vicinity, and about Oil City. Those at Pit Hole constitute another group. The quantity and quality of petroleum obtained is proportioned (the latter inversely) to the depth attained by the bore-holes. In the Cherry Run district the wells in the valley average 550 feet in depth; those at Pit Hole average 620 feet. At both these localities attempts have been made successfully to obtain petroleum by piercing the hill-sides, and that from levels above the average depth of the valleys.

(*j*). Black slate of Ohio, Ky., Tenn., or the representatives of the New York formations from the Genessee to the Marcellus slates. This is about the middle of the Devonian.

(*k*). Corniferous limestone, and the overlying Hamilton group in Canada West, extending to Michigan. This is largely productive.

(*l*). Lower Helderberg limestone at Gaspè, C. E. This is Upper Silurian, and awaits development.

(*m*). Niagara limestone, near Chicago, Ill. Not yet remunerative.

(*n*). In the equivalents of the Lorraine and Utica slates and Trenton limestone of the Lower Silurian in Kentucky and Tennessee. One well in Kentucky in these rocks was estimated to have yielded 50,000 barrels.

The immense territory in North America, several hundred square miles in extent, underlaid by the formations mentioned above, in an unaltered state, assures the world that the petroleum of the New World, like its coal, is probably practically inexhaustible.

6. Petroleum is unquestionably of organic origin. In my opinion the great mass of it has been derived from plants; but some think it comes from animals, being either a fish-oil or a substance related to adipocere. It does not appear to be the result of a natural distillation of coal, since its chemical composition is different from the oil manufactured artificially from the cannels, containing neither aniline nor nitrobenzole. Moreover, petroleum occupied fissures in the Silurian and Devonian strata long before the trees of the coal-period were growing in their native forests. The nearly universal association of brine with petroleum, and the fact of the slight solubility of hydrocarbon in fresh- but insolubility in salt-water, excite the inquiry whether salt-water of primæval lagoons may not have prevented the escape of the vegetable gases beneath, and condensed them into liquid! The hint appears to us worthy of consideration.

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*On the parts of England and Wales in which Coal may and may not be looked for beyond the known Coal-fields. By* Sir RODERICK I. MURCHISON, *Bart., K.C.B., D.C.L., F.R.S., F.G.S., Director-General of the Geological Survey.*

The ingenious suggestion of Mr. Godwin-Austen, that coal-measures might possibly be found under London and the south-eastern part of England, was formed on a general and comprehensive view, as well as upon observation. He argued that as coal is worked under the chalk at Valenciennes, in France, and had been found to a small extent in recent sinkings under the cretaceous deposits ranging westwards towards Calais, it might further extend across the Channel, and occur under similar cretaceous rocks in the south of England.

This theory, which, from the reputation of its author, attracted considerable attention, has recently been largely and boldly applied by Mr. H. Hussey Vivian, M.P., who, in a speech delivered in the House of Commons, when moving for the appointment of a Royal Commission to inquire into the quantity of British coal, expressed the opinion that this mineral might be found in the southern counties of England, and even beneath the Houses of Parliament.

Reflection upon the order and nature of the rocks which surround the south-eastern counties of England, whether on the coast of France, the Channel Islands, or the western, midland, or northern counties of England, having led me to adopt an opposite conclusion, I beg to offer the following observations in explanation of the view which I take, viz. that no productive coal-measures can reasonably be looked for in Essex, Kent, Sussex, Middlesex, Herts, Hants, Bucks, Oxfordshire, Suffolk, Norfolk, and the eastern counties, from Yorkshire southwards. In this list Nottinghamshire is happily not included. To it must necessarily be added all the numerous tracts wherein rocks older than the carboniferous rise to the surface, as in the greater part of Wales and Herefordshire, in all of which coal cannot of necessity be found.

Let us first test the value of the data afforded by observations in France, which have led to the application of the above theory to the south of England.

But although I differ from Mr. Godwin-Austen, the difference between us is not great, inasmuch that I do not believe that my distinguished friend maintains that a really valuable coal-field is likely to be found in the south-eastern counties, but simply, that some carboniferous and older rocks may there underlie the younger deposits. His memoir is, indeed, full of originality in tracing out the gradual position of an old terrestrial area over which the vegetation that formed the coal-fields probably extended.

It is true that beds of coal of considerable dimensions are worked at Valenciennes at once beneath the chalk, all the intervening formations which exist in many other parts of the world being there omitted. This fact simply indicates that at Valenciennes the coal-bearing deposits had formerly been elevated, so as to constitute ancient lands, and had not been afterwards depressed under the sea during all the periods in which the Triassic, Liassic, and Jurassic formations were accumulated in other tracts. These carboniferous strata of Valenciennes constitute a portion of the southern edge or lip of the great coal-basin of Belgium, in which country, together with the subjacent Carboniferous and Devonian limestones, they form those great undulations so admirably laid down in the geological map of M. Dumont. The portion of these coal-strata which exists in France, and which at Valenciennes dips at a high angle to the north to pass into Belgium, has been also found to have a lateral extension on the strike for a certain distance to the west beneath the Cretaceous rocks, *i. e.*, towards the British Channel.

By trials made through the Cretaceous rocks and other overlying deposits, these same coal-strata have been proved to extend to the west of Bethune. But they there gradually thin out to a narrow band, which diminishes to a wedge-like mass directed to W.N.W. The western limit of the better portion of the field has been definitely proved by the fact that, in all the borings which have been made to the east of a village called Flechenelle, Devonian limestones, schists, and grits alone have been reached, the coal being thus completely omitted.

For general purposes the geological map of France, by Messrs. Elie de Beaumont and Dufrénoy, sufficiently explains this thinning out to the west of the Valenciennes coal-field. My conclusions, however, are more specially drawn from a good statistical coal-mining survey map of France, recently prepared by able civil engineers, as laid down on the maps of the Dépôt de la Guerre, as well as from my own observations in the Boulonnais. On this map, every concession or grant of a right to sink for coal (in number exceeding 200) is marked; the results of each sinking, and the depths being regularly given. The limits of the coal-bearing strata on the north and on the south of the Carboniferous Zone have been thus ascertained by trials, all of which show that the Devonian rocks flank on each side this narrow tongue of coal-measures, the extreme point of which is at Flechenelle. Between that village and Boulogne, Devonian rocks only are found under the secondary deposits in all the borings that have been made. It is only to the north of Boulogne, at Hardingen, that a detached mass of carboniferous limestone, with an insignificant patch of worthless coal associated with it, is seen to be basined upon those Devonian rocks which there rise to the surface. In short, all the practical French geologists with whom I have conversed are of opinion that the coal-basin

of Valenciennes and Belgium terminates, as far as productive value goes, a few miles west of Bethune.

As the coal-measures thus thin out towards the British Channel, though some traces of poor coal have been found near Calais, we have a clear demonstration in the Boulonnais that no productive coal-measures are superposed to the carboniferous or mountain-limestone. In other parts, indeed, of the same district, the true Devonian limestone, with many fossils, as well as crystalline carboniferous limestone are at once covered by oolitic and cretaceous rocks to the entire exclusion of any workable coal. Judging, then, from the gradual deterioration and extinction of the coal-beds as they approach the French side of the Channel, I hold that there can be no reason to hope that better conditions can be looked for throughout the southern counties of England.

Looking, however, to the well-ascertained data that the secondary rocks of the western and central parts of England which lie beneath the chalk, viz. the Trias, Lias, and Oolites, thin out in their extension to the south-east, as well proved by a memoir of Mr. Hull, still it is by no means improbable that the part of the oolitic series which appears in the cliffs north of Boulogne may be persistent under the cretaceous and wealden rocks of Sussex and Kent. But the question is What will the fundamental rock prove to be in these districts if it should ever be searched for? Reasoning from such data and the visible outcrops in the Boulonnais, my inference is that, if not in part Jurassic, they will probably prove to be a thin band of carboniferous limestone without any productive coal, or more probably Devonian rock only. So far, then, I agree with Mr. Godwin-Austen as to palæozoic rocks (but unproductive of coal) being possibly found in the south-east of England.

Again, if we follow the course of the older rocks in France southwards from the Boulonnais, everywhere Devonian rocks only have been found beneath the secondary strata; and, proceeding through Normandy and Brittany, we find that the Jurassic rocks repose at once on lower Silurian rocks to the total exclusion of everything Carboniferous or even Devonian; whilst in the Channel Islands nothing but crystalline rocks of granite, gneiss, and slate occur, with no signs of any intermediate strata between them and the Wealden and cretaceous rocks of the Isle of Wight and Hampshire.

Tracing the line of the older rocks which separate the south-eastern from the south-western counties, we see the Devonian rocks of the Quantock Hills, in West Somerset, at once overlaid by new red sandstone, oolitic, and cretaceous rocks, without a sign of anything carboniferous. When we advance northwards from the Mendip Hills, the phenomena we there meet with are, it seems to me, indicative of the hopelessness of seeking for any productive coal-measures between these hills and the Straits of Dover, *i. e.* in Wilts, Hants, Sussex, Kent, Surrey, Middlesex, Essex, and Herts. For, on the west, the mountain-limestone forms the outward eastern girdle of the great Somerset and Bristol coal-basin from Wells and Elm, near Frome, on the south, to Chipping Sodbury, Wickwar, and to near Tortworth on the north.

Throughout a distance of about 35 miles, the carboniferous limestone with traces only of mill-stone grit, which is the unproductive bottom-rock of every coal-bearing stratum in the south of England and Wales, is everywhere and at once surmounted on the east by new red sandstone, or the lias and oolitic formations. It has been said that an exception to this rule occurs in the neighbourhood of Frome, where the unproductive limestone is said to exhibit an axial form with coal-measures on two sides. Not having been for many years in that tract, I ask for information, and will only now say that, if the coal so worked be not on the eastern flank of the limestone but on the southern side, and is not seen to dip to the east and so pass under the secondary rocks, my reasoning is unaffected.

However this may be, we know that all along the remainder of the outcrop of mountain-limestone which forms the eastern boundary of the Bristol coal-basin, the strata of that limestone are highly inclined to the west, thus passing under the Bristol coal-basin proper. Now, it is on the highly inclined and upturned edges of that mountain-limestone that the secondary rocks lying to the east at once repose,

[illegible] coal which are so thickly spread out to [illegible] basin, properly so defined, the Forest [illegible]

[illegible] the whole of the country lying to the east of the outer-[illegible] all the carboniferous rocks of the south of England [illegible] the east of which the non-existence [illegible] more striking: because, in addition to a [illegible] coal, the Old Red Sandstone [illegible] country, and on the east are im-[illegible] The same data and the same reasoning [illegible] from that tract northwards, and [illegible] Hills, as well as to all the country [illegible]

[illegible] to the north of the [illegible] Newent, in Gloucestershire, when it is [illegible] rise to the surface; their [illegible] New Red Sandstone? Equally absurd [illegible] Severn Valley of Worcester, [illegible] Malvern Hills, where the New Red Sandstone also [illegible]

The Malvern Hills on the north-west, and Charnwood Forest on the north-east, each composed of Cambrian rocks older than the Silurian, form salient promontories which seem to me to be indicative of the former southern coast-line of those productive coal-fields of the Central Counties, which have been raised up through the Permian and New Red Sandstone formations. I would not affirm that the southernmost of these fields, those of Leicestershire and Warwickshire, have no southern extension, though they give certain signs of deterioration in that direction. I know, however, that to the south of the North Staffordshire coal-field, all the productive coal-measures have been found by actual trials to thin out, old rocks of Silurian age being reached beneath. I presume, therefore, that no further efforts will be made in the more southern counties in that meridian.

On the other hand there can be little doubt that vast supplies of coal will eventually be worked to the north and west of those fields, far beneath the Permian and New Red Sandstone formations of the Midland Counties, wherein the coal-measures have been raised to the surface by upheaval through those younger deposits. Thus, in the Red Sandstone tracts between Wolverhampton and Coal Brook Dale, in Cheshire, between the Flintshire and Lancashire Coal Fields, and over other large areas similarly circumstanced, there can be little doubt that coal will ultimately be worked—a view which I advocated thirty years ago, and published in my work, the 'Silurian System.'

To return to the consideration of the wide southern area in which London lies, let us proceed due north from Reading. On this line the first ancient rocks we meet with are the slates of Charnwood Forest, which are admitted to be of Cambrian or infra-Silurian age. To the west of these, indeed, lies the Leicester coal-tract, as well as other coal-fields of the central counties to which I have alluded; but to the east, on the contrary, nothing is seen but secondary rocks,—from the New Red Sandstone and lias to the oolites and cretaceous rocks. Who, then, with such an outcrop of Cambrian slates in the west, would sink for coal in any of the counties lying to the east of Charnwood Forest and Hart Hill? The recent well-sinking at Harwich to procure water has, indeed, completely solved this portion of the problem. There, beneath 1025 feet of chalk, the trial ended in the discovery of a hard slaty rock, with fossils of the lower carboniferous limestone, evidently older than any coal-bearing stratum. Specimens of this rock are preserved in the Museum of Practical Geology, Jermyn Street, as a warning to those speculators who would search for coal in the eastern or south-eastern counties of England. This fact shows indeed conclusively, that the great Belgian coal-field does not extend eastwards to England, though the older rocks on which it rests are persistent into our country.

To widen the application of the inferences respecting those tracts where coal cannot reasonably be sought for, I may extend the reasoning to parts of Lincolnshire

and the East Rding of Yorkshire, as well as to a large portion of the North Riding of the latter county. On this head I will first allude to the south side of the valley of the Tees, a tract which I have long known, extending from Croft, by Middleton-one-Row, to the town of Middlesborough, where the New Red Sandstone, of enormous thickness, is covered by detritus and northern drift. At Middlesborough the spirited ironmaster, Mr. Vaughan, being desirous of obtaining subterranean water for the working of his engines, sunk an Artesian well to the depth of 1800 feet, and at length reached a body of rock-salt, subordinate to the New Red Sandstone, —in fact, without reaching even the surface of the magnesian limestone, through which the deep coal-pits of the east coast of Durham are sunk to the extreme depth at which coal has hitherto been worked in that county. If, then, the coal-measures should be prolonged underground to the south of the Tees (which, from my observation of the rocks between Seaton Carew and Hartlepool, I greatly doubt, as there are symptoms of a basin-shaped arrangement of the strata), and should pass under the vale of Cleveland, and the hills of the eastern moorlands, what, I may ask, would be the vast depth at which they could be won, by passing through the oolites and lias, in addition to the New Red Sandstone and magnesian limestone?

In the excellent work on Yorkshire by Professor Phillips, and indeed on all geological maps of England, it is shown that throughout a distance of many miles the lower or unproductive carboniferous rocks of limestone and millstone grit of the Yorkshire Dales are at once surmounted by the magnesian limestone of the Permian group.

On the banks of the Tees, west of Darlington, wherever the magnesian limestone forms the upper stratum, as at Conscliffe, it is at once underlaid by unproductive millstone grit, which on the west lies upon mountain-limestone; the productive coal-measure which ought to lie between the millstone grit and the Permian rocks being entirely wanting owing, either to great denudation or to an ancient elevation of the tract after the lower carboniferous period. This uprise of the older rocks seems also to form a southern border of the great Durham coal-basin. In fact, no valuable coaly matter has ever had an existence in the tract extending from Barnard Castle on the Tees, to the south of Harrogate. At the latter place and its environs, we have, further, the clearest possible proof of the omission of all the productive coal-strata; for the Plumpton rocks and conglomerates underlying the magnesian limestone, and forming, in my opinion, the base of the Permian system, are seen to repose directly on unproductive millstone grit, which, in its turn, rests upon the mountain-limestone of the western dales of Yorkshire.

But whilst I give this as not merely my opinion, and that also of Professors Phillips and Sedgwick, who have surveyed the tract in question, and also that of many sound geologists, I may state that Mr. Lonsdale Bradley, acting for my friend Mr. Webb, of Newstead Abbey, is conducting experimental borings through the Red Sandstone and magnesian limestone between Northallerton and the Tees, in the persuasion that, as the mountain- or carboniferous limestone disappears rapidly beneath the superjacent deposits to the east of Middleton Tyas, there may be found a productive coal-field, like that of Durham or Leeds, between the strata which they are now piercing and the subjacent carboniferous limestone.

This view is well explained in the diagrams which Mr. Londsdale Bradley has allowed me to exhibit on this occasion. I must, however, declare that I think the probabilities are entirely against the success of this enterprise, though as geologists we commend Mr. Webb for making this trial, by which he will have done good service to our science.

To the south of Harrogate the great coal-fields of Leeds and the West Riding appear with a well-defined boundary of millstone grit on the north and west. To the east, however, of the known boundary of these fields there is a fair probability that some coal may be found to extend under the magnesian limestone and New Red Sandstone.

As we proceed southwards along the escarpment of the magnesian limestone in its range from Yorkshire into Nottinghamshire, and thus flank successively the Sheffield and Derbyshire coal-fields, we find a progressive thickening of the coal which lies beneath the Permian rock. Whilst thin and poor beds only have as yet been worked in the south of Yorkshire beneath the magnesian limestone, we now

Nottingham is, that in the tract between Mansfield and that town, the coal-strata of Derbyshire, rich as they are, become thicker and richer as they dip to the east under the magnesian limestone. When visiting Mr. William Webb, at Newstead Abbey, in the year 1863, I had sincere pleasure in announcing this important fact in a lecture which I gave in the Mechanics' Institution at Mansfield, inasmuch as the realization of it rendered the properties of my friend and his neighbours much more valuable. The coal-pits which have almost been sunk along their lands near Hucknall and other places, are satisfactory proofs of the certainty of now finding excellent coal, superior, indeed, in quality and in dimensions to most of the coal-beds of Derbyshire, in position and in tracts where no one, even a few years ago, except geologists, thought of their existence. Indeed it is possible that at some distant day, and when the more easily attainable coals are exhausted under the magnesian limestone, the mineral will be worked under the new red sandstone to the north of Nottingham, though at depths which at present would render such operations unremunerative.

But whilst I thus advert to portions of Nottinghamshire as included in those British areas in which future supplies of coal will in all probability be obtained by sinking deep through overlying deposits, it forms no part of this communication to dwell upon this point,—still less to treat of the known coal-fields, whether they be basins subtended by old red and mountain limestone, as in South Wales or the Forest of Dean, or upcasts through the Permian and new red sandstones of the central counties. These subjects, which have already been ably handled by Mr. Hull, one of my associates in the Geological Survey, and whose work, as well as that of Mr. Jevons, has excited great public interest in reference to the duration of British coal, will, I know, be well inquired into by the Royal Coal Commission. My sole object is to exclude from the reasoning upon the English coal-fields, whether near the surface, or attainable through overlying rocks, those hypotheses which, however ingenious in theory, are, in my opinion negatived by fair reasoning on the data we possess. Thus, when we exclude, as of necessity, 21,800 square miles, or nearly one-half of England and Wales, as consisting of rocks older than the coal-measures, and in which no coal can possibly be found; and when I have further shown strong *à priori* reasons for setting aside the hypothesis that productive coal-fields may exist under our southern and eastern counties, we have first to proceed to form the best approximate estimate we can of the amount of coal left in those fields which have been long worked. Next to endeavour to ascertain what is the prospect of a profitable extraction of coal from deep-seated beds, by reaching them at certain depths beneath the superjacent Permian, or other overlying deposits, through which they have been upheaved to constitute the coal-fields of the Midland Counties. Such will be the objects of the Royal Coal Commission recently appointed; and on which I am as yet unable to give any reliable opinion.

By excluding from the inquiry into the present or probable future coal supply of England and Wales, all the tracts of crystalline and palæozoic rocks which rise out from beneath the carboniferous strata, and in which no trace of coal can ever be discovered, and also all those secondary and tertiary rocks beneath which, for the reasons given, there can be scarcely any hope of finding that mineral, it will be seen that the existing and possibly future supplies have, for all practical purposes, an approximately defined limit, and that they range over little more than one-eighth of England and Wales, or an area of about 6000 square miles.

Declining to express any opinion as to the duration of the accessible coal-beds in Britain until a closer survey shall have been completed, I fully appreciate the anxious desire which is felt by all persons who are interested in the future welfare of their country, to have the subject fully and fairly inquired into; the more so as I have now in conclusion to announce that, by the last inquiry made by Mr. Robert Hunt, the indefatigable compiler of the Mining Records in the Government establishment under my direction, the last year's consumption of coal reached the portentous figure of nearly one hundred millions of tons. Most judiciously,

therefore, did Sir W. Armstrong revive attention to this important national subject at the Newcastle Meeting of the British Association; whilst in this communication I have simply endeavoured to indicate that the public are not to believe in the almost boundless range and contents of our coal-fields which some persons would assign to them.

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### *On some Fossils from the Graptolitic Shales of Dumfriesshire.*

*By* Henry Alleyne Nicholson, *B.Sc.*

The upper Llandeilo rocks of the south of Scotland have long been known to yield graptolites in great profusion, few other forms of animal life having been recognized as occurring in them. Having had this summer an opportunity of examining the graptolitic shales of Garple Linn, near Moffat, I was struck with the occurrence in them of numerous bodies, differing from the graptolites in form, though resembling them in texture. These bodies present themselves as glistening pyritous stains, scattered in considerable numbers among the graptolites upon the surface of the shale. In their most perfect condition they appear to be bell-shaped bodies, which average three-tenths of an inch in length and two-tenths in breadth, and are provided at one extremity with a prominent spine or mucro, the other terminating in a nearly straight, or gently curved margin.

When compressed from above downwards, a condition in which they often occur, they appear as oval or rounded patches, frequently very definite in their outline, and presenting somewhere within their margin an elevated point, which is surrounded by several concentric ridges, disposed with more or less regularity. The elevated point marks the position of the mucro, and the concentric rings are merely due to vertical compression. When in this compressed condition, these bodies somewhat resemble orbicular Brachiopods in appearance.

The texture of these bodies appears to have been corneous, like that of the graptolites; but they show no traces of structure beyond the presence of the mucro, from which, in some well-preserved specimens, a filiform border is prolonged for a greater or less distance along the free margin. The mucro appears to have constituted their most solid portion, projecting as a marked elevation when obtained in relief, and leaving an evident hollow in the cast.

In most cases these bodies are free and independent, but they occasionally occur in such close juxtaposition with the stipe of a graptolite as to justify the belief that the connexion is organic, and not merely accidental. I have not observed this except in *Graptolites Sedgwickii*, the form in which this might most reasonably be expected, as the cellules are separated from one another by a conspicuous interval till close to their bases. In this case the origin of the body appears to have been from the common canal or cœnosarc. In one specimen the mucro has been preserved, and seems to have been situated at the free extremity, and therefore to have been a point of dehiscence rather than one of attachment.

The occurrence of these bodies in shales, crowded with graptolites and graptolitic germs, and their close connexion in some cases with the graptolites themselves, would seem to warrant the conclusion that they are "gonophores," or "ovarian vesicles," at first attached to the parent stem, but finally becoming free-swimming zooids. Bodies somewhat similar to these have been described by Professor James Hall as occurring in connexion with the stipe of *Graptolites Whitfieldi*, a diprionidian form, and these are regarded by him as true reproductive cells.

If this conjecture as to the nature of these curious bodies (to which the term "grapto-gonophores" might be applied) be correct, then the *Graptolitidæ* would have to be finally referred to the Hydrozoa, and would find their nearest living analogues in the *Sertularidæ*, from which, however, they would always be separated by characters sufficiently distinctive.

The facts that no traces have been preserved of any central axis within these bodies, and that they are not as yet known to occur in other localities where graptolites abound, would to a certain extent militate against this hypothesis; but the first may be due to the soft nature of such an axis, and the second is probably referable to the attention of geologists not having been directed to their existence.

*On a Peculiar Denudation of a Coal-Seam in Coates's Park Colliery, By* JAMES OAKES.

This denudation was discovered in working the "*Lower Hard*" seam of coal at Coates's Park Colliery in 1859; and it appeared to be the effect of a river which once existed, but has now disappeared, about 500 yards in width, which has as yet been traced only in a southwardly direction for nearly six miles. The whole seam (about 4 ft. thick) was broken up and deposited in disjointed masses throughout the course of this supposed river, in one instance these thicknesses of the seam being found piled upon each other; and where no coal existed, the underclay (or clunch), which ordinarily is about 2 feet thick, was heaped up, in one case, to a depth of 26 feet. A great body of water must have effected this; and the nodules of ironstone found in the underclay, by their worn shape, show that they have been subjected to the action of a strong current.

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*Further Observations on, and Additions to, the List of Fossils found in the Boulder-Clay of Caithness, N.B. By* CHARLES W. PEACH.

"At the Meetings of the Society in 1862 and 1864 I laid before the Members lists of the fossils then found in the Boulder-Clay of Caithness. In the first paper, I suggested that "the mode of transport to the shores of Caithness was by water-borne ice and not by local glaciers." That opinion I still retain. I have no objection to the deposit being called *glacial*, believing, that, in the first instance, the materials were partly derived from glaciers formed at a distance from Caithness. These glaciers descended to the sea, and were launched into it; and from them icebergs were broken off. These, when so launched, picked up some of the sea-bottom, with its organisms, &c., and when on their voyages, wherever they touched, whether on the bottom of the sea, or the shores of the land, they added to their burdens, by picking up more organisms, stones, &c.; and, when finally stranded, mud, stones, sand, and the shells of Caithness became intermingled with them. As the icebergs slowly dissolved, the burden was dropped in a pell-mell manner. The ice protected the materials, and prevented the sea from levelling and arranging them, and giving the deposit a stratified appearance. The gradual dissolving of the bergs gave time to the clay to solidify, and thus it was preserved when its carrier and protector was no more. Once firm, especially in deepish water, little injury could be done to it. It suffers most when exposed to frost and atmospheric influences. The story of the voyaging and gathering of the icebergs is well told by the contents of their left burdens; for Crag, as seen by its shells, &c., Gault chalk and greensand, by the flints, corals, and Foraminifera, with portions of chalk, both hard and soft—some so soft that it may be used for writing with—Lias and Oolite, by their *Belemnites*, *Ammonites*, fossil wood, *Septaria*, &c., Silurian, by its metamorphic limestones, quartz, and other rocks, Cambrian, by its gneiss, &c., granite, porphyry, &c., are not wanting. Then we have the abundance of Old Red Sandstone, turned up and mingled with all the above by the large bergs as they bumped and grated before finally resting. These remains form an interesting and suggestive collection. The organisms are entombed in a hard and stubborn matrix. It has, however, been made to give up its ancient dead, and to show that, at the time of its formation, life was as abundant in the sea as it is now. With few exceptions, the same species are found in it as are now living around our own shores, some few in the Arctic seas only; and probably one or two *may be* extinct. I say *may be*, from having been taught great caution by so many of those *said to be extinct* having been from time to time dragged from ocean-depths by our active dredgers.

"The fragmentary state of the organisms proves that they could not have lived and died where now found; for, with two exceptions (two small specimens of *Anomia squamula*), I have not seen two valves united amongst the hundreds gathered by myself and other fellow-workers. The only way of accounting for the escape of these delicate shells from destruction is, that they, with many other perfect minute univalves, had been sheltered in depressions in some of the ponderous masses they were fellow-voyagers with." He mentioned that chalk-flints were not uncommon in the boulder-clay and all over Caithness (even on the small island of Stroma) wherever the peat had been removed. Several species of chalk Foraminifera and

other things he had washed out of the clay. All these show that the chalk formation must have been *in situ* at no great distance from Caithness. He also alluded to the scarcity of the common litoral shells, and comparative abundance of rare and deep-sea forms, as well as mentioned other things of interest connected with the state of preservation, &c., and concluded as follows:—"I might add much more, but feel unwilling to trouble you further beyond saying that, in taking leave of the subject—it may be for ever—permit me again to mention the kindness of Mr. J. Gwyn Jeffreys, who has again named the mollusca for me. Mr. H. B. Brady, of Newcastle, has examined and named the Foraminifera; his brother, Mr. G. S. Brady, of Scarborough, the Entomostraca. To Mr. Joshua Alder, of Newcastle, I am indebted also for much advice about the organisms. I am under deep obligations to all these kind naturalists for prompt and ready attention, by which I am able to lay before you lists *that may be depended on*. For myself I beg to say that I have not admitted a single specimen into the list but those I am satisfied were taken out of the clay."

*Mollusca.*—Nucula sulcata—Norway, Ægean.
Leda pygmæa—Spitzbergen, Skye.
—— minuta—Arctic Seas, South of England.
Cardium exiguum—Norway, Ægean.
Venus casina—Norway, Canary Islands.
—— ovata—Norway Ægean.
—— gallina—Iceland and Norway, Sicily.
Cyrtodaria siliqua—Arctic Seas. Mr. Jeffreys says—"This shell is especially interesting. Dr. Rink found it fossil in Greenland."
Solecurtus candidus—Shetland, Canary Islands.
Chiton cinereus—Greenland, Ægean.
Trochus Grœnlandicus—Polar Seas, Skye.
—— Vahli—Arctic Seas.
Littorina obtusata—Iceland and Norway, Vigo.
Rissoa parva, var., interrupta—Norway, Canary Islands.
Odostomia albella—Norway, Sardinia.
—— acicula—Norway, Ægean.
Natica Alderi, var—Norway, Sicily.
Trophon truncatus—Norway, Yarmouth.
Mangelia Lefroyi—Sweden, Ægean.
—— pyramidalis—Arctic Seas.
Tornatella fasciata—Norway, Ægean.
*Crustacea.*—A fragment of carapace.
*Entomostraca.*—Cythere concinna; Cythereis Dunedinensis; Cytheridea papillosa; Cytheridea punctillata.
*Annelida.*—Spirorbis granulatus: Sandy tube of probably a Pectinaria.
*Polyzoa.*—Salicornaria; Hippothoa divaricata; Lepralia Peachii, var. labiosa; Cellepora pumicosa; Crisia denticulata.
*Foraminifera.*—Biloculina ringens; Quinqeloculina subtrotundata; Quinqeloculina triangularis; Trochammina incerta; Dentalina communis; Vaginulina legumen; Vaginicula linearis; Nodosaria raphanus; Polymorphina lactea; Polymorphina compressa; Globigerina bulloides; Cassidulina lævigata; Truncatulina lobulata; Protalia soldarii; Polystomella arctica; Nonionina asterizans; Nonionina depressula.
*Pearl* of Mytilus edulis.
*Fish-bone,* piece of.
*Summary.*—Mollusca, 21; Crustacea, 1; Entomostraca, 4; Annelida, 2; Polyzoa, 5; Foraminifera, 17; Pearl, 1; Fish-bone, 1—total of new list, 52; first list, 42; second list, 41—making altogether, 135. Of the shells, some are British, a few Arctic only; all are Scandinavian and Arctic.

*** No correction for variation has been made for the compass-bearings in the former papers.

*Gradual Change of Form and Position of Land on the South End of the Isle of Walney. By* R. A. Peacock, *Jersey.*

Sheets Nos. 27 and 28 of the Ordnance Map of Lancashire are referred to in the following account. The Map is now in the Map Department of the British Museum, and shows the coast lines of 1797, 1833, and 1847, respectively, the two first in MS.

The land, consisting mostly of sand and water-worn pebbles, continues to be washed away on the west coast, at the average rate of nearly eight feet in width per annum, round Hilpsford Point, and gradually progresses as gravel (the sand disappearing) along the beach towards south-east and north-east points, at and between which it remains, and gradually becomes covered over with loose sand drifted from the Rabbit Warren. The breadth of the land at the narrowest part on the west was about 1610 feet in 1847; and it follows that at the then rate of waste the sea will make a breach through the island about the year 2050. The gravel-bed at the south-east point, between 1833 and 1847, extended on an average nearly 12 feet annually, at which rate of progress it would fill up Haws Hole, and reach Seldom Seen Scar about the year 1930; thereby filling up the water-way leading to Peel Harbour, but in the meantime another water-way will probably have been scooped out by Peel Channel (which is in fact a river conveying to the sea the drainage of a considerable tract of country) across Far-hill Scar, so as to continue to give coasting-vessels access to Peel Harbour. If this process of removal of land has been going on, say since Ptolemy's time—and it would appear that it must have been, for the west side of the Rabbit Warren consists of sand, intermixed with *rounded* pebbles—it follows that more than 2¼ miles in breadth of land must have been washed away during the last seventeen centuries, and deposited further east. A sufficient consideration of these and similar events elsewhere, would often assist in explaining difficult passages in the descriptions given by ancient geographers and historians.

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*On Raised Beaches. By* W. Pengelly, *F.R.S., F.G.S., &c.*

The author stated that, "instead of aiming at description, his object in this communication was to call attention to certain facts which, perhaps, have scarcely received all the attention to which they are entitled."

The substance of the paper may be gathered from the following recapitulation, with which it concluded:—

"1st. That accumulations of blown sand occasionally assume the character of raised beaches.

"2nd. That it is not safe to conclude, in the absence of other evidence, that raised beaches, differing in height by as much as even 30 feet, necessarily belong to distinct periods.

"3rd. That it is possible that what, in a small vertical cliff section having the direction of the coast line, appears to be one raised beach, may really be two.

"4th. That, all other things being the same, raised beaches are likely to be most numerous on a coast composed of durable rocks."

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*On the Occurrence of* Felis Lynx *as a British Fossil. By* W. H. Ransom.

The author showed a lower jaw and part of the cranium of a species of *Felis* which had been submitted to Prof. Owen, and by him declared to belong to *Felis cervaria*, a north Asiatic variety of the Lynx. He recounted the circumstances of their discovery in a fissure in Magnesian Limestone at Pleasley, near Mansfield, associated with remains of wolves, deer, pigs, voles, and other food-animals. The jaw is preserved in the Museum of the Society of Naturalists at Nottingham.

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*On some Characters of the Brain and Skull in Plesiosaurus. By* Govier Seeley.

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*On the Carstone.* *By* GOVIER SEELEY.

*On the Characters of* Dolichosaurus, *a Lizard-like Serpent of the Chalk.* *By* GOVIER SEELEY.

*The Relation of the Upper and Lower Crags in Norfolk.* *By* JOHN E. TAYLOR, *Hon. Sec. Norwich Geol. Soc.*

The object of this paper was to prove that the present classification of shells in the Norwich Crag is imperfect, on account of an upper bed being included in the Crag. The mean percentage of the shells from the two Crags makes the relation of the Red and Norwich Crags very dissimilar, whereas there is really a near connexion between them. By separating the shells of the upper bed, the underlying Norwich Crag approaches the Red; whilst the upper bed itself forms a graduating link between the three Crags and the overlying drift beds.

After giving the established percentages of recent and extinct shells in the three Crags, as well as the proportion of Arctic shells found in them, the author mentioned several places in Norfolk where the Upper Crag may be seen overlying the Norwich Crag, as at Coltishall, Horstead, Trowse, Thorpe, Whitlingham, and Bramerton. The height of the upper bed ranges above the lower by three to fifteen feet. It is marked by the total absence of freshwater shells, by the paucity of littoral species, and by the abundance of deep-sea shells. It is also distinguished by the greater abundance of Arctic species, as at Bramerton and Thorpe, where several species of *Astarte, Cyprina Islandica, Cardium Grœnlandicum, Lucina borealis,* and others abound.

The author also showed that the shells of the Red and Norwich Crags separated them into distinct beds, whilst the same method would also separate the Upper from the Lower Crag in Norfolk. He therefore contended for the existence of *four* crags, instead of the present classification of them into *three.* This arrangement established a complete and beautiful sequence between the oldest Coralline Crag and the latest Drift deposits.

*On the Physical Geography of East Yorkshire.* *By* W. TOPLEY.

*On the Lower Greensand of Bedfordshire.* *By* J. F. WALKER, *F.C.S.*

The discovery of a new deposit of phosphatic nodules was made about three years since in the Lower Greensand of Bedfordshire, in the vicinity of Potton. This bed was formerly quarried for mending the roads, until it was found to contain the nodules for which it is now extensively worked.

A section at a cutting near Potton Railway Station shows, commencing at the bottom,—1, sand of different colours (in some places white); 2, conglomerate bed (9 ins. to 1 ft. thick); 3, sand of different colours, containing oxide of iron, about 12 ft. At a coprolite-working, on the left side of the line, looking towards Cambridge, a few yards from the edge of the cutting, the bed increases in thickness to two feet. At a large working on the hill, the conglomerate bed is about six feet thick, the section being as follows:—1, sandstone on which conglomerate rests; 2, conglomerate (6 ft.); 3, flaggy sandstone, not exceeding one foot in thickness (often less) and surface soil. The lower part of the conglomerate here is darker and more indurated than the upper. On the other side of the road is another working, where the nodules lie in a loose sand, and the phosphate-bed is about one foot thick. There are several other workings in the neighbourhood. The conglomerate contains phosphatic nodules and pebbles in about the same proportion. The bed is dug out, sifted, washed, and laid in heaps, then conveyed into sheds, where the nodules are picked over by hand. The quantity of phosphoric acid in the nodules varies from 15 to 22 per cent. The deposit consists of ferruginous sand, more or less indurated, rolled pebbles, light brown nodules of phosphatic matter

(which have an earthy fracture, and often contain remains of shells), and lumps of hardened clay. The nodules contain a much larger percentage of alumina than those of the Cambridge Greensand. This would indicate that the phosphatic nodules had been formed of clay soaked in decomposing animal and vegetable matter, since the alumina could not be derived from animal or vegetable sources. The nodules are often covered with perforations, which Mr. A. Wanklyn discovered to be the work of small *bivalves*, of which he obtained several species.

The remains of organic life found in this deposit exist in different states of mineralization. Some are coeval with the deposition of the bed, whilst others have been washed out of preexisting deposits.

Of vegetable remains are found:—

1. Large masses of silicified wood, resembling those found in the Purbeck.
2. Small pieces of wood, mineralized with phosphoric acid, and often bored by a new species of Pholas, which I have named "*Pholas Dallasii.*"
3. Cone of Cycadaceæn, from the Wealden.

Of remains of animal origin we find:—

Rolled bones and teeth of reptiles and fishes, also shells of mollusca existing in two distinct conditions, viz., phosphatic casts and ferruginous shells.

The phosphatic casts of shells are generally so much worn, that it is impossible to identify their species with precision. Their general aspect resembles those of the Kimmeridge and Oxford clays. They consist of casts of *Rhynchonella*; *Cardium*, *Arca*, *Pholadomya*, &c.; *Pleurotomaria*, *Chemnitzia*, *Natica*, &c. Also two or three species of Ammonites occur, of which *Ammonites biplex* is found in great abundance. Several of the Ammonites retain their nacreous lustre; phragmocones of large Belemnites are also found.

Part of the ferruginous shells also have been derived from extraneous sources, and among these is *Gryphæa dilatata*.

The rest of the ferruginous shells are of the age of the Lower Greensand. Amongst these there are found—

*Waldheimia Tamarindus.*
—— *celtica.*
*Terebratula depressa.*
*Pleurotomaria De Lahaysii.*
*Pecten Robinaldinus.*
*Ostrea macroptera.*
*Exogyra conica.*
*Myacites plicata.*
*Sphæra Sedgwickii*, n. sp.

Ferruginous casts of a shell resembling a "*Perna*," and other mollusca have been also found.

The remains of fishes seem to be principally derived from the Kimmeridge Clay. The following species have been also found in the Kimmeridge Clay at Ely:—

*Sphærodus gigas* (palate teeth), very common.
*Pycnodus*, sp. (palate teeth).
*Gyrodus*, sp. (palate).
*Asteracanthus ornatissimus* (dorsal spines), common.
*Leptacanthus* (spine).
*Hybodus*, sp. (spines and teeth).
*Sphenonchus.*
*Lepidotus*, sp. (scales).
*Psammodus reticulatus* (palate teeth), very common.
*Edaphodon*, sp.

The remains of reptiles are chiefly rolled bones and teeth of *Plesiosaurus* and *Ichthyosaurus*; and remains of *Pliosaurus*, which reptile is characteristic of the Upper and Middle Oolites, occur in considerable quantities.

Some teeth of Crocodilian character are found here as well as at Ely, probably belonging to a species of Quenstedt's genus *Dakosaurus*. Waterworn remains of the *Iguanodon*, and pieces of shelly limestone containing *Cyrenas*, have been derived

from a deposit of Wealden which previously existed near this district, and have been deposited in this bed subsequently to its destruction by denudation.

We see, then, that the fossils contained in this deposit consist of some coeval with its formation, and of organic remains derived from the denudation of the Wealden and of the Kimmeridge and Oxford Clays: and thus its further study will no doubt serve to elucidate a series of very interesting and important geological changes.

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*Notes on the Physical Features of the Land as connected with Denudation.*
*By* A. B. Wynne, *F.G.S., &c.*

The author called attention to a prevailing sameness of character generally observable in physical features—the results of denudation, arguing therefrom a uniformity in the action of the natural causes which produced them. Ground forms in England, Ireland, Africa and India were cited as instances to prove similarity of results, depending upon denuding agencies having been exerted upon rocks of similar kinds or in similar relative positions with regard to their strata, notwithstanding differences of climate, glaciation, rainfall, &c.

The effect of rain and atmospheric weathering was alluded to, and also that variety of denudation produced by the sea, to which, for want of a more apparent cause, the formation of plains was attributed. The difficulty of reasoning upon questions of general denudation from examples occurring in countries where atmospheric agencies included the complex actions of both rain and ice, was adverted to; and the conclusion arrived at was, that although the sea may have done much towards eating into the land, the atmospheric agencies which have been in operation ever since land first rose above the sea, even in the earliest geological periods, and down to the present time, must be admitted to have performed a most important part, if not indeed the chief results, in obliterating former traces of marine action, and giving to the land the varied physical forms which it now presents.

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## BIOLOGY.

*On the Dentition of the Common Mole* (Talpa Europæa).
*By* C. Spence Bate, *F.R.S.*

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*On the Rhizopodal Fauna of the Hebrides.*
*By* Henry B. Brady, *F.L.S., F.G.S.*

The author stated that he proposed only to supplement the Report on the Hebrides dredging, just read by Mr. Jeffreys, by a few remarks on the Foraminifera which had been found amongst the dredged sands, and to note the occurrence of certain interesting forms, either new or not before recorded from any British habitat. As the examination had not been completed, details were necessarily left to a future paper.

Of the family *Miliolida* one important addition had been made to the British list: viz., *Hauerina compressa*, d'Orb., a species rarely met with in a recent state, but well known as a tertiary fossil. Three or four specimens had been found in one of the deeper dredgings.

The abundance and variety of the arenaceous forms belonging to the *Lituolidæ* was perhaps the most striking feature in connexion with the Rhizopoda of the area dredged; and their investigations had led to some modification of the views hitherto held as to the relationship of the genera. All the previously known British species had been found, as well as three not before noticed on our shores,

namely, *Valvulina conica*, d'Orb. *Trochammina squamata*, P. & J., and *T. gordialis*, P. & J.

The *Lagenidæ* were also largely represented. *Lagena gracillima*, Seguenza, *L. Lyellii*, Seguenza, and *L. crenata*, P. & J. were new to our fauna; and the list was further augmented by two new forms having the following characters:—

*Lagena Jeffreysii*, n. s. Shell flask-shaped, often more or less flattened on four sides, ecto-solenian; neck long, and furnished with a close spiral ornamentation: surface covered with minute aciculi, sometimes worn down so as to impart a merely rough appearance to the shell.

*Lagena pulchella*, n. s. Characters as *L. marginata*, Mont., to which it is closely allied, but differing in having a number of delicate parallel costæ springing from the base and extending into the upper half of the shell, in some specimens nearly to the aperture.

*Marginulina Raphanus*, Linn., and *Cristellaria cultrata*, Montfort, were noticed; but the specimens were scarce and of poor dimensions.

A beautiful symmetrical variety of *Polytrema* and several obscure *Rotalinæ* were found; but these and some other doubtful specimens remained to be worked out.

Note.—Since the paper was read the author has learnt from Dr. Alcock, of Manchester, that three or four dead shells of *Lagena crenata* had previously been found amongst the Foraminiferous sands of Dog's Bay, Connemara.

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*On the Application of the Greek and Latin Languages to Scientific Nomenclature.* By Thomas Brown.

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*On Oyster Cultivation.* By F. Buckland.

The author began by explaining that it was difficult to give, in a few minutes, the result of a whole year's information. He would confine his remarks principally to the history of the living spat of the oyster, the chemical analysis of the meat and the mother-liquor of the oyster, to the adhesions of the various substances to which they loved to adhere, and to the marketable value of the oysters as tested by weight. He proceeded to describe the exceedingly interesting action and movements displayed by the young oyster when first emitted from its mother's shell, giving the reason why they sometimes floated on the surface of the water, and sometimes sank to the bottom, and the use to which the young oyster places its ciliæ, expressing it as his opinion that these organs never dropped off, but were absorbed after the young oyster became fixed. He then exhibited a great variety of substances to which the oysters seemed to have a natural preference for adhering. Among these were several curiosities, such as a "plague pipe," to which an oyster had fixed itself; an ordinary pipe, presented to him by Sir Walter Trevelyan, in the bowl of which no less than three oysters had taken up their position: also some old-fashioned wine or spirit bottles, from the North Sea and Loch Ryan, presented to him by Sir William Wallace. He then proceeded to describe the result of the chemical analysis which he had instituted in conjunction with A. Pythian Tarner, Esq., giving the amounts of mineral matter, the animal, and also the fatty matter. The results obtained showed that the phosphates were more important in the composition of the meat of the oyster than any other of the ingredients, and hence their great practical use for invalids and in sea-sickness. He also gave practical deductions as to choice of proper places where oysters should be laid in order to obtain a good supply of these phosphates. He then described the process of the growth of the oyster-shell, and detailed the manner in which the oyster formed the shell from the mother-liquor, the mode also by which the little oysters were enabled to form their shell inside the mother-shell. His observations enabled him to come to the conclusion as to the possible way in which the young oyster was enabled to attach itself to various articles. He had been enabled to collect samples of oysters from almost every part of the United Kingdom. These have

been accurately weighed, and he gave a table showing the relative value (commercially speaking) of oysters from oyster-beds, or proposed oyster-beds of England, Ireland, Scotland, and Wales. He stated that he was still carrying on his experiments near Herne Bay; and he was happy to be enabled to report that the French sytem of oyster-culture had been successfully carried out in a creek near Havant, not far from Portsmouth; and although he had not yet seen the results of the experiments himself, he could not help congratulating the managers upon their well-deserved success. Determined that England should be well represented, and that her oyster-fisheries should not be entirely ignored by our neighbours in France, he had at this moment one set of specimens at the Fish-Culture Exhibition at Arcachon, in the south, and another at a similar exhibition at Boulogne, in the north of that country, as well as his own collection at the Royal Horticultural Gardens, South Kensington, where he was gradually making a complete series illustrative of the culture of oysters, as well as that of salmon.

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*On the Scientific Cultivation of a Salmon River.* *By* FRANK BUCKLAND.

The author compared the ascent of salmon from the sea to the interior of the country (where it laid its eggs) to the process of following a tree from its root upwards to its upper branches. The salmon is a very clever fish; the feeling it shows when preparing to lay its eggs is so well marked, that he preferred to call it "reason" rather than "instinct." The distance which salmon ascend into hill country under the powerful feeling by which they are influenced when preparing to deposit their eggs, he instanced by their ascent of the Rhine to a distance of 400 miles, where they are stopped by the falls of Schaffhausen. Allow the salmon to lay, he said, and it will abundantly repay the care; put ladders on weirs for it to swim up, not nets to catch it. The salmon has many enemies—hakes, cormorants, and herons; otters also hunt the salmon, not only for food, but as we ourselves do, for sport. Of all the enemies the salmon has to contend against he has not a more terrible than the millers. When a salmon comes to a water-wheel it will stay by it for days. The miller stops the wheel, and lets down a trap at the lower end of the mill-race and catches the fish. Steamers, too, are its enemies; and though the salmon is not a nervous fish it is delayed by them. It is very sensitive to smell; when it comes near large towns it will not venture to pass up rivers filled with impurities. What does it do then? It waits until a flood comes, and then ascends in purer waters. Waterfalls are no friends to the salmon. There is a waterfall at Knaresborough. People thought the salmon used to jump every Sunday morning to please them, but the fact was the millers were obliged by law to let the water down on Sunday, and then the fish leaped. Poachers are great enemies of salmon. During the winter months it was not an uncommon thing for one poacher to destroy many fish. He heard from a converted poacher a confession that made his hair stand on end—he used to feed his pigs with salmon eggs! Mr. Ashworth, of Galway, has now the model fishery of the United Kingdom. The wonderful increase in the number of fish caught, and therefore its money value, showed the use of cultivation. To cultivate a salmon fishery, however, one must not lie in bed in winter; this business admits of no idleness. Mr. Ashworth asked the salmon poachers how much they made by poaching during the winter, and gave them double the money to let the spawning fish alone. He had from 120 to 130 men employed to see that the salmon were not disturbed during the winter. He himself was proud of having opened up the river Stour at Canterbury. There had been no salmon (*Salmonidæ*) for many years—a net had been placed across the river. A deputation waited on the mayor and corporation, an association was founded, and the result was, the Salmonidæ were on the increase. The Thames used to be a salmon river. The Eton boys used to catch "skeggers;" but now there were none in the Thames, for the salmon were not allowed to go up by the weirs erected on account of navigation. If they were allowed to go up, there would soon be sufficient eggs. He himself had hatched in his back kitchen 30,000 eggs. He was pleased to say that a salmon had been brought to him which had been caught at Gravesend in a whitebait net.

He trusted it was from one of the eggs hatched either by himself or by the Thames Angling Preservation Society. He collected the fishermen at Gravesend, and they said that for more than thirty-three years a salmon had not been caught there before. He was certain that if the cultivation of salmon in the Thames were attended to, in a few years this valuable fish would be restored to the river.

Mr. Buckland then gave some details respecting the Exhibition of Fish-culture at Boulogne. He was happy to say that this congress did great good, commercially and intellectually, inasmuch as representatives of all nations—from Norway and Sweden in the north, to Spain in the south—met to interchange ideas, as well as to establish business correspondence. He had received one silver and two bronze medals from this Exhibition, as well as a silver medal from the Exhibition at Arcachon for his labours in fish-culture.

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*On* Comatula rosacea, C. celtica, *and other Marine Animals from the Hebrides.* *By* Dr. Carpenter, *F.R.S.*

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*A few thoughts, Speculative and from Observation, on Colour and Chromula.* *By* J. J. Cleater.

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*On the Entozoa of the Dog in relation to Public Health.*
*By* Dr. T. S. Cobbold, *F.R.S.*

In this extended communication the author gave an account of twenty-one different species of canine *Entozoa.* Amongst the most important forms were the *Tænia echinococcus* and the *Trichina spiralis.* In regard to the latter he remarked that "it was probably not indigenous in the dog; but the ease with which the parasite was transmissible obliged us to class it as a canine parasite." He had frequently reared it in the dog. Except in an indirect manner the dog would not be likely to give the *Trichna* disease to man; nevertheless, if infested dog's flesh were eaten by us we should undoubtedly take the disease. At all events, there was danger in allowing trichinized dogs to roam at large, since the consumption of their flesh after death (by other animals) tended to propagate the disorder. Rats especially would thus become liable to the disease.

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*On the Teaching of Science at the Public Schools.*
*By the* Rev. F. W. Farrar, *M.A., F.R.S.*

After alluding to the strangeness of the fact that science, to which the most characteristic progress of this epoch was due, should have been hitherto disregarded at our oldest seats of learning, the author proceeds to argue that the introduction of scientific instruction into the public-school system was necessary on three grounds: first, because it called into play a *different* order of faculties in boys who had studied language with success; secondly, because it evolved those faculties in boys who were naturally unsuited for classical training; and thirdly, because the schools had ceased to be solely preparatory for the Universities, and were therefore bound to give boys the opportunity of acquiring some knowledge which would be of direct practical use to them in their future professions. He next treated of the difficulties in the way of carrying out these views. Those difficulties did not in the least arise from the prejudice of public-school masters, the majority of whom had used their best efforts to introduce more or less of scientific teaching into the schools, but from the conflicting opinions of scientific men, from the absence of any definite and well-considered scheme, from the badness of many existing text-books, and from the immense amount of time already devoted to the teaching of the modern languages, mathematics, and classics, a term which now involved a very wide range of studies. The author suggested that many of these difficulties might be removed if a committee were appointed by the Association, partly composed of scientific men

and partly of masters accustomed to the methods of public schools. He stated that at almost every school something was being done, but that the plans mainly adopted were three; viz., 1. Modern schools in which science was made a part of the course; 2. occasional and compulsory lectures, of which notes were taken by the boys; and 3. a voluntary system, by which boys were *encouraged* rather than *compelled* to make themselves acquainted with various sciences. Rugby is the only school at which science is now regularly and completely introduced; and the author therefore described the system there introduced, and the no less characteristic voluntary system which has been established with much care at Harrow, and which is working most advantageously. Finally, the author suggested his own scheme, which was a combination of the voluntary and compulsory systems, for which in the case of many boys ample time could be gained by a wise abandonment of the practice of Greek and Latin composition—an abandonment which (in the case of all but first-rate scholars) he warmly advocated as most desirable after a certain age.

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*On the Power which some Rotifers have of attaching themselves by means of a Thread.* *By* R. GARNER, *F.L.S.*

In this short paper the author observed that Rotifers are not common in sea-water, though one, *Colurus uncinatus*, may be found in any tank. That especially noticed, however, *Synchæta Baltica*, is more choice in its habitat, though it may always be found in water from the mouth of the Mersey, from Rhyl, or Llandudno. The author has not noticed it to be luminous. It evidently has the power of forming a very fine thread from its posterior extremity, by which it attaches itself to other bodies; and when so attached it performs those remarkable circular movements described by Gosse; its ciliated side processes being powerful locomotive organs. During the performance of these movements the thread may be inferred to be present, from small particles adhering, and it may be made visible with the highest power of the usual microscope, $\frac{1}{4}$ inch: the Rotifer can snip it with its pincers at its pleasure, when it goes off with great velocity. Other Rotifers may have a similar power, as indeed is mentioned by Cohn in the common Hydatina.

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*Variations in the Great Arterial Blood-vessels.*
*By* GEORGE DUNCAN GIBB, *M.A., M.D., LL.D., F.G.S.*

Deviations in the origin of the great vessels from the aorta were seldom or never recognized during life; whether they exerted any liability or disposition to morbid action, the author thought improbable. In the first of his examples the aorta gave off four branches, instead of the usual three. These were the left carotid and subclavian, arising in the usual manner, and the right carotid and subclavian, each arising direct from the arch of the aorta by a distinct and separate trunk, there being an absence of the innominata. The two vessels on the right side were larger than the left; the left carotid was the smallest of the four. The course of these vessels was the usual one, but the laryngeal branch of the superior thyroid artery of the left side perforated the thyroid cartilage, instead of passing inwards through the thyro-hyoid membrane in the usual manner. Both femoral arteries, and the left great ischiatic nerve varied in their division; all the arteries of the extremities were calcified into hard unyielding cylinders.

In the author's second instance, the main trunk or ascending portion of the arch of the aorta divided into two great branches, the first of which subdivided into the innominata and left carotid, the latter crossing the trachea obliquely upwards to the left side; the innominata divided into the two usual branches of right subclavian and carotid. The other subdivision of the arch was into the left subclavian and descending aorta, both vessels taking their usual course. If his interpretation of this peculiarity were correct, the author considered it a unique instance of division of the aorta into two branches which in their subdivision gave off the proper trunks. No similar example had been found, even in Mr. Quain's great work; and the inference was that it was unique. The division of the aorta in this second example was not unlike that of the abdominal aorta into the two iliacs.

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[illegible] By Professor Oswald Heer.

[illegible] *Flora in the West* [illegible] Professor E. Forbes. *By* H. Hennessy, F.R.S.

[illegible] By John Hoare.

## *On the Ballast-Flora of the [illegible] and Northumberland**.

*By* John Hogg, M.A., F.L.S., F.L.S., &c.

The author in his remarks on the plants which have been introduced with ballast in some of the docks of Durham and Northumberland, limited himself to the docks and quays on the banks of the rivers Tees, Wear, and Tyne.

At the mouth are the great ballast-hills at Port Clarence, and those at West Hartlepool and East Hartlepool, and the embankment of the railway to the north of the latter town. The hills of ballast at Seaham, at Sunderland, and near Tynemouth, as well as those at South and North Shields, and others along the Tyne banks at Newcastle.

The lists of the numerous species were divided into two heads—viz., I. *Exotics* or plants [illegible] and II. the *more conspicuous* or *naturalized* species of Great Britain, which were most seen in the before-named districts.

The number of imported species in the first list amounts to 69 species; and that of plants mentioned in the second division is 124. These numbers include the species which have been, during many years past, discovered by Messrs. Winch, Storey, Norman, and Lawson, as well as by the author.

The ballast of the localities specified is mostly chalk with flints, and therefore many plants which are usually found in calcareous formations, are there found. Yet Mr. Hogg stated that several orders of plants are unrepresented: as, for example, there are no *Orchideæ*, not even any of those species of *Orchis*, which flourish in calcareous soils: and no *Saxifrageæ*: one or two of the commonest *Rosæ*, *Rubi*, and *Ranunculi* only occur.

It was noticed that after some years' observations, the more tender species, especially the *exotics*, flourish for two or three years, but that they perish either by the frost of the first hard winter, or by the severe east winds in the spring. Also several sorts of British plants, which were seldom if ever met with before the numerous railways were made, have been carried with shingle along the lines of railway, and so have now fully established themselves.

They have not, however, as yet caused any great decrease in the more common plants of the district.

It was further remarked that after the ballast had been deposited, *Annuals* mostly sprung up, but that in two or three seasons they gave way to a variety of *Perennials*, which succeeded to them.

Mr. Hogg inserted in his paper several lists of plants, which he had carefully prepared.

## *On the Asexual Reproduction and Anatomy of* Chætogaster vermicularis (*Müll.*). *By* E. Ray Lankester, *of Christ Church, Oxford.*

This species of Chætogaster is a minute chætopodous worm, one-eighth of an inch long, parasitic on the common water-snail. Its most remarkable peculiarities are, the presence of oral bristles differing from those of the body, the very small number of segments composing it, and the total absence of reproductive organs. The author described its anatomy minutely, and its mode of reproducing by budding.

*This paper is published nearly *in extenso* in the 'Annals and Mag. of Natural History,' No. 100, for January 1867.

### *On the Indians of Vancouver Island.* By J. K. Lord.

The author gave a description of the customs of the Indians, their weapons, domestic animals, together with other most most interesting peculiarities. He began by showing that the numbers of these Indians were steadily decreasing; he described their personal appearance as being strangely modified by the habit the coast tribes have of sitting continuously in their canoes and in their lodges. Especial reference was made to the curious fact that the teeth of most of the inland Indians are ground down to the gum by the sand which is drifted on to the salmon when exposed for drying in the sun; for it is upon this dried fish the savages subsist entirely during the winter months. The author exhibited an under jaw, in which the teeth were thus worn away. He pointed out the curious fashion the people have of altering the form of the skull during infancy, either making it flat or conical, by means of pressure. Engravings of these skulls, &c. are given in the author's 'Naturalist in Vancouver Island.' The strange ideas relative to the disposal of the dead and the rites of burial were also mentioned. The author then gave many particulars relative to the native dogs, and the probability of a dog having been imported from Japan which had a long, silky coat; the natives used to shear these animals as we shear sheep, using the coat for the manufacture of rugs; but since the introduction of blankets by the Hudson's Bay Company, the dog has disappeared from want of protection, and become extinct. He showed that the art of weaving was known to these tribes at a very early period of their history. The religion of these people is very remarkable, and they entertain beliefs in sacred days and periods and sacrifices to the sun; they believe in witchcraft and in deities representing good and evil. Animals, plants which are eatable, fish and birds, were believed to have been at one time human. The remarkable custom of obtaining the "medicine," to guard them through life, called "tomanawax," was described. They measure the sequence of the seasons by the ripening of berries and opening of flowers, the arrival of the crane and wild goose, spawning of fish, &c. Copious vocabularies of the different languages, and the jargon called Chinook, as spoken by the different tribes west of the Rocky Mountains, were submitted to the Section. The names and words seemed to be harsh, and decidedly unmusical. He then explained a valuable collection of stone weapons dug by himself from the ancient river-gravels of the upper Columbia river; these were intermixed with stone beads, shells of the Ventaliodd, the parasitic barnacles found on the skin of the whale, buttons made from sea-shells, human skulls and bones. These relics were buried at a great depth, and no trade exists at present betwixt the Indians there resident at the present time with those dwelling on the sea-coast; the distance from the sea is nearly a thousand miles. The author drew new and important conclusions from these facts. Lastly, the lodges and canoes were described, and these, it appears, vary among the different tribes, each tribe to a great extent having a form of canoe peculiar to itself. A wonderful "*medicine*," called a "copper," was exhibited, from Fort Rupert, painted on its surface with brilliant colours, depicting quaint heraldic devices; also a large slate dish, most exquisitely and elaborately sculptured by the Haida Indians living on Queen Charlotte Island. Many other rare objects were exhibited and described. The author brought home a large collection of natural objects, to which frequent reference was made. These are now deposited in the British Museum.

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### *Results of the Cinchona cultivation in India.* By Clements R. Markham, *F.R.G.S.*

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### *On a New Molluscoid Animal allied to Pelonaia* (Forbes and Goodsir). By Dr. C. M'Intosh.

The specimen was found on the beach at St. Andrews, after a severe storm, in 1861, measuring 1¾ inch in length, in shape like an elongated Florence flask with the bottom a little produced and the neck much elongated. Its test is constructed like sand-paper, the particles forming essential constituents of the mass; and at the wide end there is a series of hairs formed by prolongations of the basis structure,

with sand particles and mud attached. Within this test lies a series of interlaced muscular fibres, which cross each other at right angles, and which muscular coat can be easily separated from the internal (and somewhat fibrous) surface of the test. The branchial sac is elongated, has its meshes of a square or slightly oblong form, ciliated at the edges, and is continued along the narrow part of the animal to the terminal apertures, the oral one of which has no tentacular fringes. Its structure, so far as the specimen was preserved, was detailed, and it was mentioned that its digestive system agreed in general with Pelonaia. In conclusion, the species differs from Pelonaia, as described by Forbes and Goodsir, in the extreme prolongation of the portion sustaining the apertures: and in the structure of the test, which in *P. gigas* is thin and diaphanous, like parchment, and in *P. corrugata* thick, cartilaginous and transversely wrinkled, while here it is like sand-paper. The shelf or transverse ridge in the interior of the mantle, as shown in the figure of *P. gigas*, is absent. It differs also very characteristically from the Bolteria.—The same author communicated some remarks on the Turbellaria and Annelida of North Uist, of which he had found about 110 species, including many rare and some new examples. He also exhibited numerous coloured drawings of new and rare marine animals recently got in the Hebrides and St. Andrews Bay.

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*On a Rare Mollusoid Animal* (Pelonaia corrugata).
*By* W. C. M'Intosh, *M.D., F.L.S.*

This was at first considered to be a new species, from the erroneous or imperfect descriptions previously published, especially that in the 'British Mollusca' of Messrs. Forbes and Hanley. A minute description was given of its appearance and anatomy;—its unyielding flask-shaped sheath of sand particles, covered with sandy hairs towards its bulbous portion, and to which sheath the muscular coat does not adhere closely: its elongated branchial cavity, curious digestive system, &c.

Large coloured drawings of new and rare marine animals from the East and West coasts of Scotland were also exhibited.

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*List of Turbellaria and Annelida of North Uist.*
*By* W. C. M'Intosh, *M.D., F.L.S.*

The list of Annelida from North Uist consists of about 110 species, some of which have hitherto been procured only at rare intervals, either in Britain or on the Continent, while others are new to science. Amongst the rarer forms may be noticed *Lineus albus*, *Stylus fasciatus*, *Serpentaria fragilis*, *Polynoë scolopendrina*, *Lepidonotus clava*, *Spinther oniscoides*, *Gattiola spectabilis*, *Eteone pusilla*, *Scalibregma inflatum*, *Ophelia acuminata*, *Travisia Forbesii*, *Terebella maculata*, *Terebellides strœmii*, &c. The rare or new forms come under the genera *Leptoplana*, *Borlasia*, *Ommatoplea*, *Lepidonotus*, *Lumbrinereis*, *Nerine*, *Trophonia*, *Phyllodoce*, *Clymene*, *Terebella*, *Aphlebina*, and *Dendrostomum*.

Attention was called to the fact that every specimen of *Polynoë scolopendrina* was found in the tube of a littoral Terebella. This habit of frequenting the tubes of other annelids is not uncommon in its allies. The *P. scolopendrina* was also phosphorescent.

The author mentioned that Mr. Gwyn Jeffreys, F.R.S. had just placed in his hands a large collection of deep-water forms from the Hebrides, so that a considerable addition to the foregoing list might be expected.

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*On the Zones of the Coniferæ from the Mediterranean to the Crest of the Maritime Alps.* *By* W. Moggridge.

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*On the Occurrence of* Lemna arrhiza *in Epping Forest.* *By* W. Moggridge.

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*On the Food and Economical Value of British Butterflies and Moths.*
*By* O. Groom-Napier.

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*On the Cause of the Variation in the Eggs of British Birds.*
*By* O. Groom-Napier.

*On the Crustacea, Echinodermata, Polyzoa, and Cœlenterata of the Hebrides.*
*By the* Rev. A. Merle Norman.

*On the Structure and Growth of the Ovarian Ovum in the* Gasterosteus Leiurus. *By* Dr. W. H. Ransom.

The author described the mode of growth of the early ovarian ovum, and drew attention to the contents of the germinal vesicle, which he showed to be gelatinous; to the germinal spots, which he showed to be drops of a thick fluid, apt to undergo singular changes of form, somewhat resembling those met with in pus corpuscles; and to the yelk sac, which he showed was present at a very early stage of the formation of the egg; and he endeavoured to prove that it increased in all dimensions by interstitial deposition.

*On the Systematic Position of the Pronghorn* (Antilocapra americana).
*By* P. L. Sclater, *M.A., Ph. D., F.R.S.*

The author stated that his chief object in the present communication was to bring into more prominent notice a very important discovery regarding this animal, that had been made in the Zoological Society's Gardens in the Regent's Park during the past year, and had formed the subject of a paper read by Mr. Bartlett, the Superintendent of the Gardens, at one of the Society's meetings in 1865*. This discovery was, that the horns of the Pronghorn were naturally shed every year—a phenomenon hitherto quite unknown among the Bovidæ or hollow-horned Ruminants, with which the Pronghorn had always hitherto been associated, and only occurring in the allied Deer-family or Cervidæ. Mr. Bartlett's observations had been made upon a young male of this scarce mammal, which had been acquired for the Society in January 1865†, and had since lived in good health in the Menagerie. This animal had shed both its horns on the 7th of November, 1865; and a finer pair had since grown, which would, no doubt, be shed in like manner in Nov. 1866. Since Mr. Bartlett's publication of this novel fact, full confirmation of it had been received by the Zoological Society, in a communication from their Corresponding Member, Dr. Colbert A. Canfield, of Monterey, California, who had come to the same conclusion as Mr. Bartlett, from observations on this animal in a state of nature made in the county of Monterey, in some parts of which the Pronghorn was very common‡.

The author exhibited a skull of the Pronghorn with the horns fully developed and ready to be cast off shortly, and explained the mode in which he supposed the shedding to be effected. After the old horn was cast off, the horny matter, which was at first entirely confined to the upper end of the new horn, gradually spread itself down to its base, enveloping the numerous hairs with which the new horn was clothed when first appearing, and ultimately checking their growth and destroying their vitality. After the horn was perfected and hardened, new hairs developed themselves beneath the epidermis, and, not being able to force their way through the horny covering, became, as the author believed, the chief agent in causing the shedding of the horn. As regards the general structure of the horns of the Pronghorn, it was quite evident that they had little or nothing in common with those of the Deer. The latter were formed of bone developed upon a process of the frontal bone, and were more correctly termed *antlers*, whereas the horn of the Pronghorn consisted of true horn (like those of the ordinary Bovidæ) gradually developed from the epidermis, the skin remaining complete underneath them.

Two other points in which the Pronghorn differed from all the other known

* "Remarks upon the Affinities of the Prongbuck," by A. D. Bartlett, Superintendent of the Society's Gardens. (Proc. Zool. Soc. 1865, p. 718.)

† See notice and figure, Proc. Zool. Soc. 1865, p. 60, pl. 3.

‡ See Dr. Canfield's paper "On the Habits of the Prongbuck, and the periodical shedding of its horns," Proc. Zool. Soc. 1866, p. 105.

Bovidæ, were the furcation of the horns and the absence of the "false hoofs," as the stunted terminations of the rudimental second and fifth digits of each foot are termed, in which latter respect it resembled the Giraffes (*Camelopardalis*). These three important modifications of structure, when taken together, induced the author to believe that it would be necessary to raise the genus *Antilocapra* to the rank of a family in the series of Ruminantia, which he proposed to arrange somewhat as given in the subjoined Table.

## Order ARTIODACTYLA.

### Division RUMINANTIA.

I. RUMINANTIA PHALANGIGRADA.

Placenta diffusa. Stomachus tripartitus: dentes primores $\frac{1-1}{3-3}$, canini $\frac{1-1}{1-1}$, molares $\frac{6-6}{6-6}$, aut $\frac{5-5}{5-5}$: pedes didactyli..... 1. *Camelidæ*.

II. RUMINANTIA UNGULIGRADA.

*a*. Placenta polycotyledonaria. Stomachus quadripartitus: dentes primores $\frac{0-0}{3-3}$; canini $\frac{0-0}{1-1}$, aut $\frac{1-1}{1-1}$; molares $\frac{6-6}{6-6}$.

*a'* Pedes didactyli, ungulis succenturiatis nullis.

*a''*. Cornua in sutura coronali posita, ossea, brevia, pelle tecta ..... 2. *Camelopardalidæ*.

*b''*. Cornua ex osse frontali orta basi ossea, parte superiore cornea, furcata, decidua ..... 3. *Antilocapridæ*.

*b'*. Pedes tetradactyli ungulis, succenturiatis duabus.

*c''*. Cornua ex osse frontali orta, basi ossea, parte superiore cornea, non furcata, permanentia ..... 4. *Bovidæ*.

*d''*. Cornua ex osse frontali orta, omnino ossea, decidua... 5. *Cervidæ*.

*e''*. Cornua nulla, dentes canini marium exserti ..... 6. *Moschidæ*.

*b*. Placenta diffusa. Stomachus tripartitus; dentes primores $\frac{0-0}{3-3}$; canini $\frac{1-1}{1-1}$, molares $\frac{6-6}{6-6}$; pedes tetradactyli; cornua nulla 7. *Tragulidæ*.

In conclusion the author called attention to the geographical distribution of the Ruminants, as shown in the subjoined Table, in which the geographical divisions employed were the same as those used by the author in his paper on the distribution of Birds*, but which he believed to be equally applicable to the class of Mammals.

Table of the Distribution of Ruminants.

| | Orbis novus. | | Orbis antiquus. | | | Regio Australiana. |
|---|---|---|---|---|---|---|
| | Regio Neotropica. | Regio Nearctica. | Regio Palæarctica. | Regio Æthiopica. | Regio Indica. | |
| 1. Camelidæ | ..... | ..... | *Camelus* | | | |
| 2. Camelopardalidæ | *Auchenia* | | | | | |
| | ..... | ..... | ..... | *Camelopardalis* | | |
| 3. Antilocapridæ | ..... | *Antilocapra* | | | | |
| 4. Bovidæ | ..... | (*Haplocerus*) | *Antilope* | *Antilope* | *Antilope* | |
| | ..... | ..... | *Capra* | *Capra* | *Capra* | |
| | ..... | *Ovis* | *Ovis* | ..... | *Ovis* | |
| | ..... | *Ovibos* | | | | |
| | ..... | *Bos* | *Bos* | *Bos* | *Bos* | |
| 5. Cervidæ | ..... | *Tarandus* | *Tarandus* | | | |
| | *Cervus* ..... | *Cervus* | *Cervus* | ..... | *Cervus* | |
| | ..... | ..... | ..... | ..... | *Cervulus* | |
| 6. Moschidæ | ..... | ..... | *Moschus* | | | |
| 7. Tragulidæ | ..... | ..... | ..... | ..... | *Tragulus* | |
| | ..... | ..... | ..... | *Hyomoschus* | | |

* Journ. Proc. Linn. Soc. ii. p. 130.

*On the Distribution of Mosses in Great Britain and Ireland as affecting the Geography and Geological History of the present Flora.* *By* JOHN SHAW.

*Notes on the Structure of the* Echinoidea regularia, *with Special Reference to their Classification.* *By* C. STEWART.

*On the Traces of an Irish Lake Dwelling, found by* Captain L'Estrange, *in the County of Cavan.* *By* W. TENNANT.

*On a Remarkable Mode of Gestation in an undescribed Species of* Arius. *By* Professor W. TURNER, *M.B., F.R.S.E.*

In this paper a new species of *Arius*, from Ceylon, which the author named *A. Boakeii*, after the Rev. Barcroft Boake, of Colombo, Ceylon, by whom it was first sent to this country, was described. This fish lays eggs about the size of small bullets, which the male fish takes into his mouth and retains there until the young are ready to leave the egg. About twelve eggs come to intra-ovarian maturity at one time, which is the number that the male can hold in his mouth. Although Messrs. Wyman, Günther, and Agassiz have described American fish which have the same habit, this is the first specimen of a fish of the Old World in which this remarkable mode of incubating the ova has been observed. The paper, with various anatomical and zoological details, is printed *in extenso* in the 'Journal of Anatomy and Physiology,' November 1866.

*On Reversed Sexual Characters in a Butterfly, and their Interpretation on the Theory of Modifications and Adaptive Mimicry (illustrated by specimens).* *By* A. R. WALLACE.

The author exhibited a Malayan butterfly (*Diadema*, n. sp.) the male of which was of a dull brown colour, while the female was richly glossed with metallic blue —colours which in all the allied species are characteristic of the male sex. He then showed that the female butterfly so closely resembled the very common *Euplæa midamus* that it could not be distinguished from it on the wing. The *Euplææ*, and the whole family Danaidæ to which they belong, as well as the Heliconidæ of South America, are protected groups, and are the subjects of imitation by many other butterflies and moths. The special protection the Danaidæ possess was supposed to be their very strong and peculiar odour, which rendered them distasteful to insectivorous birds; and the reason why the female only of the *Diadema* had acquired protection by closely resembling the *Euplæa* was, because in all insects the female is of more importance than the male, and it is necessary, in order to ensure the continuance of the race, that her life should be preserved while she is engaged in depositing her eggs. This was held to be a crucial instance of the truth of the Darwinian hypothesis; as what appeared at first sight a strange and unaccountable anomaly, was shown to be under certain conditions the necessary consequence of the "preservation of favourable variations in the struggle for life."

*The Poor Man's Garden.* *By* N. B. WARD, *F.R.S.*

*On some points in the Structure of* Limulus, *Recent and Fossil.* *By* HENRY WOODWARD, *F.Z.S., F.G.S.*, &c.

In this communication the author pointed out that although the classification proposed by Professor M'Coy for *Limulus*, *Belinurus*, and *Eurypterus* in 1849 was founded upon very imperfect data, yet subsequent researches tended to show that a near relationship did exist between the *Xiphosuræ* and the *Eurypteridæ*.

Mr. Woodward cited the published observations, descriptions, and figures of species belonging to these two groups, by Professors Agassiz and Hall (in America), Dr. Nieszkowski (in Russia), Professor Huxley and Mr. J. W. Salter (in England), and Mr. W. H. Baily (in Ireland), and he likewise referred to his own investigations in confirmation of his views.

The author entered at some length into the anatomical structure of *Limulus*, *Belinurus*, *Eurypterus*, *Stylonurus*, *Pterygotus*, *Hemiaspis*, &c., in order to show that by a series of intermediate forms which have of late years become known, he was able to reconcile the apparently wide diversity existing between *Pterygotus* and *Limulus*; and he submitted that they may appropriately form two subdivisions of the order *Merostomata* of Dana.

These views have since been published by Mr. Woodward at length in the Quart. Journ. Geol. Soc. London, vol. xxiii. (No. 89, Feb. 1, 1867, p. 28) with illustrations. See also monographs of the Palæontographical Soc. for 1865 (Dec. 1866), Pt. I. of the *Merostomata*.

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*Notes on* Lithosia caniola. *By Dr.* E. Perceval Wright, *F.L.S.*

This species was discovered by Mr. Barrett on the Hill of Howth, near Dublin, in 1860—so very local was its habitat that it might be said to be found only on one closely sheltered bank on the south side of the hill. Since 1860, many specimens have been taken by Mr. Birchall, Mr. Dunlop, and the writer; and the limits of the species, so far as Howth is concerned, would seem to be on the increase. How this South European insect obtained a settlement on one point of the Irish coast and in no other part of the British Islands, was, Mr. Birchall confessed, a curious problem, which he ventures to solve, by supposing it may have been introduced in the larva state among moss and lichens. In the spring of 1866 Dr. Wright was botanizing on the coast of Waterford, when he was struck by the close similarity in appearance between certain portions of the Tramose strand, and that where the *L. caniola* was found at Howth: it had the same aspect, the same plants, and was just the place where one would expect to find the species; but it was too early in the season for it. In the course of the summer Dr. Wright requested his brother to collect all the *Lithosia* to be met with at the place; and, as he had anticipated, *L. caniola* was among them; one of the specimens was slightly different from the ordinary form of *Caniola*. In addition to adducing this new locality for this insect, Dr. Wright mentioned his belief that *L. caniola* was little more than a climatal variety of such a form as *L. complanula*.

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*Botanical Notes of a Tour in the Islands of Arran, West of Ireland.* *By* Dr. E. P. Wright, *F.L.S.*

The islands consist of limestone, forming on their western sides high frowning headlands, and on those facing Galway Bay a series of coarse shingly beaches, interrupted here and there by several sandy bays. The surface of the larger island presents the appearance of a series of gigantic tombstones arranged in vast tiers, the interspaces between the large slabs of stone and the faces of the terraces containing almost all the plants to be found on the island. Dry stone walls abound everywhere, sometimes enclosing plots of ground only a few feet square; and by the help of these enclosures some few crops are sown and garnered. In some cases the potatos are planted on the bare rock, and covered over with a basketful of earth and seaweed; in others the rock gets covered over with a thin sod, which supplies a precarious nourishment to a few sheep brought from the mainland. Dr. Wright stayed eleven days on the island, visiting now and then the middle and south islands. The weather was most unfortunate, and scarcely a day passed over without rain, while a strong north-west wind, blowing with great force, made the constant jumping over stone walls particularly trying. The season was too far advanced for many of the characteristic Arran Island plants; still a sufficient number of interesting species were met with. Dr. Wright first enumerated the list of species actually collected, for convenience of reference using the nomenclature of the 'Cybele Hibernica' of Dr. Moore and A. G. More, the publication of which, though too late this year to do much for Irish botany, would, he doubted not, mark a new era in the investigation of this subject. He next proceeded to mention those plants which might be considered remarkable or rare, or which had not as yet been recorded as found in the district marked VI., according to the scheme adopted in the 'Cybele.' Among these he alluded to the *Aquilegia vulgaris*, found on the northern part of the large island; *Helianthemum canum*, *Sedum*

*Rhodiola*, *Gentiana verna*, of which nothing but the leaves remained; *Solanum dulcamara*, *Marrubium vulgare*, *Allium Babingtonii*, found on all the islands, and very widely scattered over the large islands; *Adiantum capillus-veneris*, &c. Several common plants, such as *Sisymbrium officinale*, *Cochlearia officinalis*, *Torilis nodosus*, &c., were mentioned simply to supply the deficiency in this respect in the 'Cybele.' On the exposed western side of the island many ordinarily met with plants were remarkable for their peculiar stunted growth. Thus the samphire, which grew in the greatest abundance, was found in full flower, and yet hundreds of the plants were not more than three inches in height; and plants of *Sedum rhodiola* were met with scarcely more than two inches in height. In all such cases the plants were growing in the chinks between the stones. A dwarfed condition of growth was not, however, by any manner of means the rule, for under favourable conditions fronds of the Maiden-hair fern were found twenty inches in length. Specimens of *Verbascum thapsus* were met with nearly five feet high; and in one instance a cluster of that fine thistle, *Silybum marianum*, was seen three or four of the flowering-stalks of which were five feet four inches in height. Dr. Wright next proceeded to contrast the Flora of the Arran Islands with that of the coast of Clare, referring to Mr. Foot's very interesting paper on the Burren flora, in the Transactions of the Royal Irish Academy, for this purpose; and suggested that the general affinity of the flora was rather to the Clare than to the Galway coast. This would at first sight be expected, seeing that Arran is, geologically speaking, but an extension of Clare. Almost every plant met with on the islands is met with in the Burren district, and *vice versâ*, whereas many plants are met with in the Connemara district which are not found either in Clare or Arran. The inhabitants are indebted altogether to the mainland for their supply of fuel; and the turf which they chiefly use is brought from the immediate neighbourhood of Roundstone and Birterbuie Bay. To this circumstance Dr. Wright was inclined to ascribe the appearance of some few plants which were found very plentifully about the villages of Kilronan and Kilmeany, and yet not at all inland, such as *Coronopus didyma*, *Urtica urens*, &c. In conclusion, Dr. Wright trusted that these notes, made under very disadvantageous circumstances, might not be without some interest. Every one, he thought, was bound to contribute what he could (no matter how small that contribution might be) to make our knowledge of the Flora of Ireland complete.

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## PHYSIOLOGY.

### *Address by* Professor HUMPHRY, *F.R.S.*

IT is, I feel, no small honour to be called upon to preside over this section, which represents the very highest branch of physical science. I say the highest branch of physical science, because it has to deal with the highest and broadest of physical problems. The animal frame, which it is our work to investigate, stands at the summit of the great physical cone, with man at the apex, by whom it is, as it were, slung from heaven, in whom the material is worked up to the point of contrast with, and made subservient to, the purposes of the spiritual. Indeed so complex is the animal organism, so intricate and varied are the questions in physiology, that it is apt to pass out of the range of science, and become too much a matter of speculation and an object of mystery; so that there is some danger of its being degraded by the very difficulties and features which should really place it in the highest position among sciences.

Infinitely varied in its forms and structure, suited to every conceivable condition, where air, moisture, and heat are present, yet developed from one simple type, composed of various elements combined in the most intricate manner with endless modifications of mechanical, chemical, and electrical processes, besides others which it is scarcely possible to recount or observe, much less to comprehend, and which we group under the term "vital," the animal machine presents interests for every mind, puzzles for every genius, and challenges the whole army of science and philosophy through all coming ages to concentrate their fire and attempt even their

outer works. Impelled by the irresistible impulse for knowledge, cheered by continual victory, we march, and not slowly, ever onwards, and value our laurels none the less because each fresh one tells of more that must be won, and shows the final goal receding as we near it.

Finding, as we do, that the animal machine is the resultant of all the properties or forces of matter, combined and harmonized by that most mysterious of them which we call the "vital force," we claim as fellow labourers the workers in every division of science, and watch with interest each discovery, knowing that in whatever direction it is it has a bearing, more or less direct, upon our own study, welcoming all, digesting and appropriating what we can.

Both as regards the ground, therefore, which has been already turned, and that which remains to be explored, physiology affords the grandest field for labour and provides occupation for every faculty. In no other science, perhaps, do observation and reflection so distinctly stimulate and help one another. It is chiefly by clear reasoning, by induction from ascertained facts, that physiology is to be studied and advanced; and though a short flight into the regions of imagination now and then may show a beacon light and help us better to track the path to knowledge, the lights there seen are too commonly *ignes fatui*, exciting and misleading. Hence the study of physiology is one of the best exercises of the mind; and the greater appreciation of it as such is being shown by the admission of it, slowly and cautiously it is true, into our educational system. It is taking its place in our Universities; and I am convinced that it and the other branches of natural science will be found at least as suitable instruments for cultivating and strengthening the various faculties of the mind, particularly those of observation and reflection, as any of the more favoured educational subjects. In looking to the future of young England, and its prospects in the struggle (the hard struggle), I will not say for existence, but for position among nations, that seems to be impending, one cannot but feel that very much must depend upon the effectual development of the mental faculties. It has been by force of mind and not by force of coal that our country has been raised to its present height. We must look to the same power to keep her in the full front of nations. It is not the bayonet, it is not the needle-gun, but the mind that conceives and the energy that makes and wields them, which gain the victory. If, as I am sometimes disposed to think, the old educational soil, upon which so many generations have been trained, is in some degree wearing out, it will surely be none the less productive for the introduction of new elements; at any rate they will bring out fresh powers to meet the changing circumstances of the times. I will not, however, detain you with this, but pass on to one or two other matters.

For the higher reasoning, combining, and analytic faculties, abundant scope and exercise will be found in the attempts to unfold the laws by which we grow, and move, and have our being; and full reward is given by the glimpses, from time to time, we obtain of the wondrous workings of creative power. As an illustration of this, I need only mention the discovery of development by cells, a discovery which is, perhaps, second only to that of gravitation, evincing as it does a simple, uniform law, underlying and working out the vastly diverse forms and structures of vegetable and animal life. Surely the knowledge that the tough oak-plank, the blade of grass, the lion's claw, the contracting muscle, and the thinking brain all emanate from simple forms which, so far as we can tell, are perfectly alike, and, further, that the entire plant or animal also emanate from a single form or cell which is undistinguishable from the rudiments of its several parts, is as full of interest and as suggestive of high thought as any one of the fragments of knowledge which man has worked out for himself in the whole range of physical science; and what better exercise can there be than teaching the operation of the great law of uniformity of plan from this simple starting-point, and witnessing the manner in which it holds its ground through all the infinite modifications by which plants and animals are adapted to their several positions and to one another.

The microscope has lately been to physiology much what the steam-engine has been to manufacture and transit; it has opened up new regions for observation, and given an entirely new direction to our thoughts. The structure of the several tissues and organs has probably been made out as far as the present means permit,

and we are occupied now in investigating their mode of formation and connexion with one another. There seems much reason to think that they are more closely related, more continuous, than we have been in the habit of regarding them. There is now little doubt of the continuity of the nerve-fibres and the nerve-vesicles; and it is not improbable that the other parts of the nerves are continuous with the several tissues among which they ramify, with the deeper prolongation of epithelium, with the elementary structure of muscle, and with the filaments of areolar tissue. The continuity of the areolar tissues with serus, fibres, and mucus membrane on the one hand, and with the intimate structure of the various organs on the other, is more clearly shown, and a very general and extensive continuity is thereby established. The cornea is continuous with the sclerotic, and so with the speri sheath and dura mater. Even epithelium, which we were wont to regard as a distinct external and easily separable sheath, is found to send its filamentary prolongations into the subjacent organs, which become blended with the areolar and nervous and perhaps with the lymphatic systems. The epithelium of the glandular tubes is in some organs undistinguishable from the cells which occupy the stigma. The blood-vessels in many animals are continuous with the areolæ of the tissues; and in all, the ultimate circulation take place through the tissues, the nutritious fluid passing freely to and fro between their interstices and the interior of the capillaries where capillaries are present. We are thus reminded of the fact that in their embryonic period the several structures, or the potential rudiments of them, were all blended in a homogeneous germinal mass; and we learn that though they have become differentiated they have not become separated, but retain in their mode of connexion the traces of their common parentage and of their early continuity. Such a blending of ultimate tissue, as a remnant of embryonic condition, assists us to explain many things, such as the transfer of impressions and what we call sympathy, that are at present difficult to understand, and is an additional illustration of the simple method by which, in nature's works, great ends are attained.

We perhaps scarcely realize and appreciate the bearings of the fact that all the various tissues are formed from a primitive homogeneous and continuous plesina, by the formation and separation from one another of "portions," "centres," "masses," "cells," or whatever we please to call them, and their development into structure; attention has been directed almost exclusively to the formation and development of these masses and too little to their *separation*, though the latter is a process little, if at all, less important than the former, and must be effected by something analogous to what we call abruption. Indeed the work of abruption, or hollowing out, during the embryonic state is little less active than that of secretion or building up. We are familiar with its work in the formation of the areolæ and cavities of bone, in the removal of the parts of the iris and eyelids that do not become developed into permanent structure; but we are not perhaps sufficiently impressed with the fact that the various cavities, canals, and spaces in the interior of the body are due to the same progress, and that the failure or arrest of it may be the cause of many of the so-called adhesions of seams and other surfaces, of the imperforate condition of canals, and the union of parts that should be free. The transition from the investigation of the fine processes of the animal organism to the consideration of the forces by which they are brought about is a natural, a necessary step, though, I need scarcely say, it takes us into a region where advance must be slow and where difficulties seem almost insurmountable. We are probing more into the very deepest recesses of nature, and inquiring into her closet secrets. We feel ourselves here almost to be

> "Children crying in the darkness,
> Children crying for the light,
> And with no language but a cry."

Yet cry we must, and in time we shall get some, though perhaps never a full reply; indeed when the questions that here arise shall have been fully answered, when man shall be entirely satisfied as to the essential nature and the first causes of that which he sees, when these deep problems shall be worked out, when the penetralia of nature's temple shall be thoroughly explored, science will have told its tale, and the physical world will cease to afford its arousing interest for us. Of such satiety

we need have no apprehension. Increasing knowledge only further shows our ignorance, that kind of ignorance, at least, which gives more stimulus to knowledge; and thus the acquisition of knowledge and the attendant consciousness of ignorance together, carry us on till the time when we shall know as we are known.

It is quite clear what we call CHEMISTRY, with its attendants heat and electricity, plays a most important part in the animal machine; and, probably, more information as to the nature of the organic processes is to be expected from their chemical study than in any other way. We have found out that there is a very close relation between a complete atomic formula and the vital processes, the amount of chemical tension which is expressed by the former being commensurate with the character of the latter, and the amount of chemical change which takes place in the textures being commensurate with the activity of the vital processes. There seems good reason to believe that a muscular fibre is the container of a given amount of chemical force compressed by the medium of a high chemical formula, and existing, therefore, in a high state of tension, that during its construction the compressed force is set free by the decomposition of its structure, that is, by the resolution of its component elements, chiefly by a process of oxidation, to a lower formula or a state of lower tension, at the same time that heat is evolved and electrical changes take place, though the latter are not yet distinctly defined. It is impossible, therefore, to avoid the application here of the doctrine of contractile force, which is being so clearly worked out in the inorganic world, and which seems to be the greatest advance that has for some time been made in our knowledge of the laws of matter. We can scarcely doubt that the chemical force which is set free during the decomposition attendant upon muscular action is the equivalent of the contractile force that is evinced and of the heat that is evolved. In other words, a muscle may be regarded as the medium by which force is accumulated, rendered latent, or condensed in a condition of high chemical tension, and is, from time to time, as occasion may require, set free and converted into muscular or contractile force and heat.

It seems probable that such is the case, and we may look for the more clear demonstration of it with some confidence as a real gain to physiology, inasmuch as certain of the animal formations will be thus withdrawn from the mysterious region of life into the more intelligible domain of science.

Not that we must make too much of this and be too proud, and assume that, because we are able to refer a little more of animal process to the ordinary phenomena of matter, we may relinquish the idea of a vital agency altogether. Let us first remember that we really know very little of those phenomena, not much more than we do about life. Attraction and chemical affinity, heat, light, electricity, magnetism, and motion, are all expressions for forces of the nature of which we are, and perhaps shall ever remain, ignorant. They may be, and probably are, modifications of one force, and one force showing itself in different ways; and it is something to arrive at this. It may be that life is another modification of the same force; and it will be something more to arrive at that. We need not shrink from such a result; but we have not yet attained to it, and have no right to prejudge that it is, or that it is not, and to quarrel with those who hold a different opinion. Suffice it to admit that there is still much in vegetables and animals that we cannot explain by reference to the ordinary laws of nature, and which we refer to another law or power and call it life. For instance, in the case of muscle just alluded to, though the state of chemical tension may explain much, we know not how that tension, that complex formula, is brought about; we cannot approach to an imitation of it. We know not how it is maintained. We know not how the force so pent up is liberated and converted into muscular action. We cannot explain these phenomena, much less those of growth and development, by reference to the chemical or other properties of matter, and until we can, we must be content to fall back upon the additional mysterious agent of life.

So with certain other vexed questions which are, in some measure, allied to this one. Can, or rather does, any combination of the ordinary forces of matter ever lead to the phenomena of life? If they are proved to be correlative with the vital force it might seem that some show of probability would be given to such a view. But we must remember that for the manifestation of vital force a living being is,

so far as our observation at present goes, absolutely necessary; that is, life has never been known without a living being, without a form, without a medium for the exercise of the vital force, just as there is no manifestation of attraction or heat without the medium (matter) through which they act. Thus we are impaled upon the horns of the dilemma—life is not manifested without a living being or medium, and the medium cannot exist without life—a dilemma from which our knowledge of the properties of matter is, so far as I can see, unequal to rescue us; and our only refuge is in the admission of a creative power to which the medium and properties of life, in the same way as the medium and ordinary properties of matter, owe their simultaneous existence. We must allow this for the present, without reference to the future progress of discovery; and, without being seduced into that over-much wisdom which is another expression for folly, must be content to reason from what we know. Further observation may supply other bases for our reflection and widen the area of our thoughts by showing that matter is endowed with properties which enable it to aggregate into living forms, but no sufficient ground for such an assumption has yet been given.

A subject for investigation, nearly akin to that last mentioned, and which may, perhaps, some day, tend to throw some light upon it, is the transition from life to death, a change which, under ordinary circumstances takes place in the most delicate, insensible manner; so that it is impossible to say when and how life ends and death begins. I speak not of that wide and sudden termination of the body's life from disease or decay (that somatic death) which we usually associate with the word "death," but which is in nature comparatively so rare that it may probably rather be regarded as exceptional and abnormal than natural. I refer to the mode in which the parts of the ultimate tissue of the body become changed and cease to exist, a process so fine as to elude observation and to prove that the boundary line between life and death is hard to define. Even in the instance of the cuticle, a structure comparatively under the eye, as we watch the transition of the spherical deeper components to the flattened forms of the superficial strata, and the disintegration of the latter, partly by external influences, we are at a loss to decide where living force ends; indeed there seems to be no point at which that can be said to take place. And if, with regard to the components of it and the other tissues, we assent to the view that their external or "formed" parts are lifeless and their internal or "germinal" parts are alone endued with living properties, we still have to ask, Where is the division between the two? Where does the "germinal" or living end, and the "formed" or lifeless begin, and how is the latter done away with? Clearly it is not by an abrupt disintegration or solution, but by some slow insensible process which savours rather of atomic change than of destruction. Then, one is inclined to ask, if the passage from the living to the unliving condition be of this insidious inappreciable nature, may there not be a converse of a like kind, an insensible origination of, or conversion into, life and life's forms, going on somewhere in the far recesses of nature's womb. I do not think we are bound to shut out the thought of such a possibility. It seems a fair question to entertain; but admitting it as a question, we must refrain from the tendency to give a hasty answer in the affirmative.

Granted, therefore, for the present, that the medium, the living form, was given or created with the vital property, does it remain the same in kind through all succeeding generations? or is it capable of undergoing changes, slowly and gradually, or, perhaps, if needs be, more rapidly, so as to adapt it to various circumstances and conditions, so as, in short, to evoke in time the diverse forms which animal life is known to assume; or must each of those forms have been the result of a special creation similar to those which we suppose in the first instance? One might have judged this to be a question which a careful examination and comparison of the different species, and the circumstances under which they are found, would have enabled us to decide with tolerable ease and certainty; but it was found not to be so. On the one hand we see changes in each individual whereby the complete being is evolved from the simple germ, changes that are suggestive of a corresponding evolution of the varied animal forms from one humble beginning. We find all the different animals emanating from the same point as its centre, the simple germ which presents precisely the same features in them all. We find them

all carried along the same high road of development and diverging to acquire their respective peculiarities; so that certain structural types are largely traceable among them, binding them together and suggestive of a common origin. We can arrange them in gradational series, not one series but several, of which one emanates in man. We find each animal so suited to its position and so surely disappearing when the conditions cease to be favourable to it, and as a necessary consequence of the alteration of those conditions, as to suggest that it was modified from a common standard not merely *for* but *by* the conditions which surround it. The records of the earth's history prove this adaptation to have been the case in former times as well as now, the faunas varying in correspondence with the variations in the surface and climate and temperature of our planet; and we can clearly prove certain modifications in species to be caused by changes in the external conditions in which they have been placed. Moreover, by attention to external curiosities and selection in breeding, we can induce deviations in the offspring, and so imitate, it has been suggested, the process that goes on in nature.

These, with some other considerations, coincide with our scientific yearning to unfold the plan of the universe and trace in its growth and the development of its parts the operation of natural law. They seem to give us hints as to the mode of construction of the animal kingdom which it is the legitimate work of physiology to gather up and weave into a consistent theory according with some new conceptions of creative plan.

But, on the other hand, so high a point on the hill of knowledge (a point imagined rather than yet seen) can be but slowly reached. Much labour is required to clear away the thickets and level the ground, lest the springs of genius carry us down rather than up. Much observation must be made and much evidence accumulated before we can see our way to a theory of transmutation of species. The only valid, but it is a cardinal, objection to such a theory is the want of evidence that a change of the kind inferred really takes place, and that so little proof of it is forthcoming in spite of the attention which has for many years been anxiously directed to the subject. The nearly allied species tantalize us by a certain flexibility of type and by their near approach to one another; but they seem rigidly to abstain from the boundary lines; and the variations that take place seem to have no especial reference to an approximation to those lines, but rather to a certain power of accommodation to external circumstances necessary for the preservation of the species. We find considerable varieties of the human species. We do not clearly yet know how to connect even these with one another or with a common origin. Some of these are more, some less, allied to the monkey; but between the lowest of the human and the highest of the monkey there is a gap, the width of which will be differently estimated by different persons, but so wide that there has never yet been any doubt to which side any specimen should be referred. Now, if the one has been transmuted from the other, how comes it that the series has been broken and the connecting links ceased to exist? The conditions are still favourable to the existence of the man and to the existence of the monkey; why are they not still favourable to the existence of the species that have connected the one with the other? we may wonder, not only that the traces of species in *past* time are not forthcoming, but that the species are not *now* living. Moreover, we do not know that any conceivable conditions, operating through any number of years, would bring the gorilla or chimpanzee one whit nearer to man, would give them a foot more capable of bearing the body erect, a brain more capable of conceiving ideas, or a larynx more capable of communicating them. It is possible that such changes might be effected. One would fancy it probable; but we have at present too little right to assume it, and the more extended the research without increasing the evidence the less does the probability become.

Neither do I think that much direct assistance has been given by the theory of *natural selection* based upon the *struggle for existence*, ably propounded after long and careful research and ably defended as it has been; it has dispersed some of the fallacies and false objections which beset the idea of transmutation of species, and has so placed the question in a fairer position for discussion, but it reminds us forcibly of some of the real difficulties and objections. Though artificial selection may do much to modify species, it is rather by producing varieties than by draw-

ing away very far from the original stock. To the former their seems no limit; but the latter is stopped by the increasing unproductiveness and unhealthiness of the individuals, by the susceptibility to disease, and the tendency to revert to the original type. So that increasing departure requires greatly increasing care; and we do not know that any amount of care and time would be sufficient to produce what might fairly be called a new species. The bringing about any marked change by nature's selection is shown to be very hard of proof, and has opposed to its probability the fact that the members of a species which are most unlike have the greatest tendency to pair and are the most fertile; so that we have here, in addition to the ready reversion of modified breeds to the original stock, a law by which the growth or perpetuation of peculiarities is prevented and a constancy given to the characters of the species. This law is more striking from its contrast with the bar that exists to the pairing of different species and the infertility of hybrids. Within a given range dissimilarity promotes fertility; beyond that range it is incompatible with it.

These and other considerations have always inclined me to the opinion that modifications of animal type, occurring in nature, are more likely to be the result of external influences operating upon successive generations, influencing their development, their growth, and their maturity, than of "natural selection" and "struggle for existence." But greater effects of these and other similar agencies must be shown before we ought to admit even the reasonable probability of their power to work out the great changes that have been attributed to them.

In pondering over the definiteness of animal types, so marvellously elaborated from a simple form, their slight variability through long periods, the clear manner in which they, many of them at least, are worked out from one another, and which increasing investigation seems to render more and more apparent, the prospect of proving that they are educed from one another by any of the hitherto supposed processes seems to grow more and more distant, and the feeling arises that there must be some other law at work which has escaped our detection.

We are familiarized with the fact that in the inorganic world combinations take place only in certain definite proportions; for instance, that oxygen unites with nitrogen in one proportion to make nitrous oxide in a second proportion, a multiple of the first to make nitric oxide, and so on to the fifth proportion or multiple, which gives nitric acid, and that between them five several fixed proportions as combinations take place. So that the resultants of these and other similar combinations (the inorganic species, as we may call them) are remarkably constant and fixed in their characters; each has its one form, as in the case of crystal, of chloride of sodium, or sulphate of magnesia, which may be broken down or dissolved, but which cannot be modified or made to approach, still less to pass into, any other form.

May there not be something analogous (some corresponding law of combining proportion) presiding over living matter, educing the various forms, fixing their characters, giving them constancy, in fact evolving and fixing the species and preventing their transmutation.

It will be understood that I am not speaking of the combining proportions of the elements in the several animal tissues, which we know, or have every reason to believe, is as fixed as in ordinary inorganic matter, though the combinations are more complex and the formulæ are, in consequence, harder to work out. I speak now not of this, but of something comparable with this and suggested by this, operating not upon individual particles, but on masses, regulating not the chemical composition and form and feature of the tissues, but the form and features of the animal. As oxygen unites with nitrogen only in the definite multiple proportions represented by the figures 1, 2, 3, 4, 5, and under certain circumstances, producing in each instance a special compound unlike any other and marked off from the nearest approaching compounds by distinctive features, and without any intermediate gradations, so in the animal and vegetable world the combinations requisite for evolving living beings may be regulated in a similar manner, taking place only in certain fixed proportions and under certain circumstances and educing certain definite forms, each of which is unlike any other and is marked off from its nearest approach by clearly distinctive features and without intermediate grada-

tions. As each chemical compound (say nitric oxide) remains in its given condition, without change, till circumstances have culminated to favour and induce a change, which then takes place, not by slow gradation, but by sudden start, to some other definite compound (say nitrous or nitric acid), so the several animal forms may remain fixed till the conditions for a change, which conditions may be external to themselves, are complete. Thus the change may take place, and not by slow gradations, but by sudden start, by something resembling a new creation, and their definite and clearly distinct form, or species, is produced. Thus, as complementary and similar to the laws of uniformity in design and variety in detail, we may suppose to work on together the laws of gradation and interruption—by the one the living ladder is shaped and bound together as a whole; by the other the steps are preserved distinct, *i. e.* the individuality of the species is given and retained.

At any rate, whatever be the law and forces which effect and regulate the evolution of species, they are probably of the same kind as those which are operating in the inorganic world. The orderly and definite manner in which forms and features and specific characters are given and preserved in the one instance may be assumed to be of the same nature as in the other; and we must probably refer the fixed animal and vegetable types to influences identical with, or similar to, those by which the forms are assigned to crystals and the stratification is given to rocks, by which the geological epochs have been determined and the boundaries of our planetary and solar systems have been set. One cannot but think that it may be within the power of man to work out and to comprehend, in some degree at least, the principles by which these breaks in the organic and inorganic works, constituting as they clearly do an important feature in the plan of creation, are brought about and regulated.

The pendulum of opinion on this great question (the question of working by general law, or working by special interferences) may be expected long to swing to and fro ere it rests upon a settled conclusion. In the meantime it will help to keep the wheels of science going and add fresh knowledge to our heap.

And let us not shrink from the free, bold, fair discussion of these and other kindred subjects under an apprehension that they are calculated to lower the religious elements and shake the faith. Such discussions, and the thoughts which give rise to them, are a necessity, an inevitable result of advancing science, which it is as impossible to stop as the progress of time itself; and that which is inevitable must be accepted. 'Twould show a want of faith to resist it. Knowledge may be man's trial; but that applies to knowledge of all kinds, of that which is esteemed good as well as of that which is esteemed evil. Certainly the fruit of its tree brings responsibility; but responsibility is man's highest dignity, and opens one of the avenues to the tree of life. Theological zeal and scientific zeal are both good, and representatives of good elements in man's nature—the element of faith and the element of thought. Both should cooperate in the work of purifying and elevating the character; indeed the one cannot advance safely without the other. Still they will now and then come into collision and threaten to undermine one another, needing forbearance and discretion to restore their harmony. One cause of the occasional outbursts of the *odium theologicum* is, I think, due to a fault on the side of the theologians. Not satisfied with, or distrusting the really unassailable position on which their future stands, with its foundations deep laid in man's consciousness and God's work, they have endeavoured to raise outworks on the shifting ground of natural science, by drawing arguments from analogy, by associating special views of creation and resurrection with true religious belief, and by insisting on certain literal interpretations of the physical medium through which spiritual truth has been conveyed to us. Hence each unfolding of the material laws is liable to be regarded with suspicion, lest it should sap the foundations that have been thus unwisely propped. Religious arguments drawn from the physical world are very liable to prove two-edged swords cutting both ways according to the manner in which they are wielded, or staffs that penetrate the hands of those that lean upon them. Theology may rest safe upon her own position, and watch with confidence and satisfaction the advancing waves of science,

feeling assured that, though they may beat at times rather roughly upon her, they will soon calm down under her leavening influence, and simply add too and strengthen her soil.

And we may work patiently on, not pressing hastily to conclusions which our aspirations seem to point to, but relying on careful observation and honest reasoning to give us a solution of some of the great problems which animal life presents.

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Letter communicating the result of an application to the General Medical Council as to a Grant for investigating the Physiological Action of Remedies, from Dr. ACLAND.—The application had been refused, on the ground that such investigation was not within the sphere of the Council's duties.

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*On the Effects of the Pollution of Rivers.* *By* Col. Sir J. E. ALEXANDER.

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*Remarks on the so-called Cattle-Plague Entozoa.* *By* Dr. COBBOLD, *F.R.S.*

The author pointed out the importance of understanding the precise nature of these bodies. They were not, properly speaking, Entozoa, but were psorospermial sacs of microscopic size. He found them varying from $\frac{1}{180}$" to a greater length in cattle, and less than $\frac{1}{112}$" in sheep. They were extremely abundant in the heart. The contents of the sacs displayed a complete cell-formation, the ultimate particles being granular. Each granule or pseudo-navicel, as it might be called, measured only the $\frac{1}{1000}$" in diameter; some were round, others oval, a few reniform. Under very high powers minute refracting points or nucleoli were observable in their interior. Practically, they were harmless and could be swallowed with impunity. (At the Evening Soirée Dr. Cobbold exhibited specimens under the microscope.)

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*On the Colour of Man.* *By* Dr. J. DAVY, *F.R.S.*

The author first enumerated the various shades of complexion in connexion with the localities in which they are found, and then went into the subject of causation. The warmer the climate, the less the difference of colour of arterial and venous blood. The Esquimaux are neither fair nor dark brown, but intermediate. The long, continuous solar effect for one half the year associates them with the inhabitants of the tropics, whilst their living underground the other half does not favour the depuration of their blood. With regard to the Chinese, he ventured the conjecture that their colour may be owing to an imperfect elimination of bile; that it might become hereditary and pass in course of time into that distinctive of climate. He showed that the circumstances of a cold or temperate climate favour fairness of the skin. Of this he gave a variety of instances; and invited discussion on a subject of no ordinary interest in regard to health and beauty.

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*On the Question, Is the Carbonate of Lime in the Egg-shell of Birds in a Crystalline or Amorphous State.* *By* JOHN DAVY, *M.D., F.R.S., &c.*

A high authority in physiology, M. Milne-Edwards, seems to consider it in the former, in a crystalline state: his expression is, that in the enveloping membrane it has a crystalline appearance*. The grounds for this, his opinion, he does not give, nor does he enter into any minute details on the subject.

From such observations as I have made on the egg of the common fowl and on the eggs of other birds, especially of the smaller, I am disposed to the adoption of the opposite conclusion, viz. that the carbonate of lime in the shell is in an amorphous and finely granular state. In this state I have found it in the egg of the common fowl, taken from the oviduct when the carbonate of lime was only sparingly deposited in the investing membrane. Again, in the instances of the eggs of the smaller birds, which are exceedingly thin, are easily crushed and reduced to a fine powder, well fitted for microscopical examination, I have never

* He says, "Celle-ci (the shell) est formée par une couche plus ou moins épaisse de cellules vésiculaires dans l'intérieur desquelles du calcaire carbonaté ne tarde pas à se déposer et à prendre une apparence cristalline."—Tom. viii. part 2, p. 527.

observed any appearance of crystals, only of granules, these of various sizes, the smallest only just within the limits of vision. Further, when I have subjected a minute portion of shell to the blowpipe, and rapidly destroyed by combustion the animal matter, in the residual lime comminuted with a drop of water added to it there has been no appearance *immediately* of crystals, only of granules: I say *immediately*, because, after a short exposure to the air, the lime, that which had been deprived of its carbonic acid, reuniting with carbonic acid derived from the atmosphere, then assumed a crystalline form, and presented minute well-defined crystals, chiefly of the cubical kind, and this the more rapidly the more free the exposure, as shown by comparing a portion covered with thin glass and another not so covered. And if no water be used, no solution formed, then no crystals were produced, even when the lime, attracting moisture from the atmosphere, becomes converted into a hydrate*.

That crystallization is of rare occurrence in connexion with organic development is an admitted fact, and where it has been observed, as in the blood, it seems to be yet a problem waiting solution, whether the crystals detected were formed in the living fluid and were a part of it as such, or were formed after privation of life; in other words, whether by a formative process analogous to secretion, or by a destructive process pertaining to excretion. That coagulable lymph or fibrine may lose its vitality whilst in the living blood-vessels, and undergo a softening similar to that which takes place in it out of the body at a certain temperature, is now an established pathological fact; and as blood-corpuscles are always included in the coagulum, these two may be inferred to be in the same category in relation to vitality. Were life and crystallization compatible, might we not expect to find crystals in bones? But I am not aware that they have ever been detected in any bone, however early its examination may have been in the embryo. It may perhaps be said that crystals are frequently met with in calculi. Admitting the fact, is it not more reasonable to refer their formation in these bodies not to vital action, but to the absence of vitality, and to ordinary physical causes, calculi themselves being anorganic, and the result of causes of the same kind, *i. e.* physical? And here I may mention a fact which I am disposed to view in the same light. I have found in the ovary of a fowl a white opaque matter, resembling in appearance lithate of ammonia, as seen in the urinary excrement of birds; but on examination it proved to be not a lithate of ammonia, but carbonate of lime mixed with animal matter, the former partly granular and partly crystallized, chiefly in minute cubes.

The rapid manner in which the carbonate of lime is deposited on the egg in the oviduct, and always, as it would appear, associated with animal matter, might perhaps be used as an argument against its deposition on the membrane in a crystalline form: be this as it may, both the shortness of time in which the incrustation takes place and the quantity of carbonate of lime which enters into the incrustation is remarkable. A hen, a good layer, in full vigour, commonly lays an egg every day, and I have never found more than one egg in the oviduct at the same time. Of an egg newly laid, which weighed 906·9 grs., the entire shell was found to weigh 69·4 grs., of which, on analysis, 16·1 grs. proved to be animal matter, 53·3 grs. carbonate of lime, with a trace of carbonate of magnesia and phosphate of lime; so this large quantity of carbonate of lime must have been poured out from the blood in the short space of twenty-four hours or less!

Another fact I would mention, which also may be adduced in favour of the idea that crystallization is not incompatible with vital action. I refer to the microscopical crystals, chiefly prismatic, which are found to occur in the brain and spinal chord of the frog and toad, and which I have detected also in the newt, and this normally, as far as I am aware, without exception, and, I may add, which occur also in profusion in the retina. From the trial I have made of them, they appear to consist chiefly of phosphate of lime. The existence of these crystals is a fact that does not seem to admit of the same explanation as calculi. It seems altogether exceptional—a problem waiting solution.

In certain vegetables, too, as is well known, crystals have been found in their

* Hydrate of lime, formed by exposing quicklime to the atmosphere, I have found finely granular and free from crystals.

cells; but it is questionable whether they are anywise essential to the growth and well-being of the plants, and are not rather the results of disease, depending on a state of the fluids, somewhat analogous to that which in animals is favourable to the production of calculi. It would be foreign to my purpose to express any opinion as to the great question whether, in the vital economy, the forces in action are merely physical forces, or, admitting, as must be admitted, that these forces are concerned in the phenomena of life, whether something more is not required, a special force, a vital force, to give them direction, or modify their influence.

*Note on an Addition to the Sphygmograph.* *By* Dr. Balthazar W. Foster.

After describing the construction and application of Marey's Sphygmograph, the author pointed out that the screw regulating the amount of pressure exerted on the artery under examination required adjustment for nearly every case. Too great pressure often materially altered the form of the pulse trace; and as it is essential for accuracy in comparative observations that the pressure on the vessels should be the same, the author stated that by having an index attached to the pressure-screw, and a graduated circle described round the screw as a centre, the position of the index would always enable the observer to exercise the same amount of pressure in any number of cases.

*On a Peculiar Change of Colour in a Mulatto.* *By* Dr. Balthazar W. Foster.

After alluding to the present state of our knowledge of the conditions connected with the development of pigment, the author related an instance in which he had observed a gradual disappearance of the cutaneous pigment in a Mulatto aged 43. Minute white spots first appeared on the man's back, and by coalescing gradually formed large white patches. These constantly extending, in the course of six years the whole of the trunk became perfectly white, spots of the original colour remaining only on the extremities. The face retained its dark hue, and an irregular margin encircling the neck formed the limit of the upward advance of the white colour. Isolated spots of white had appeared, however, on the forehead and at the angles of the jaw. The white skin was perfectly healthy in appearance and not to be distinguished from that of a European. The man's hair was black and crispy, and of a flattened elliptical form on section. Blisters applied to the bleached surface restored the dark colour in irregular spots, which remained unchanged for several months. No discoverable condition in the man's constitution or habits could be regarded as the antecedent of the remarkable change, except possibly a very weak and sluggish state of the circulation. A series of large photographs illustrated the communication.

*On the Action of Carbonic Oxide on the Blood.* *By* Dr. A. Gamgee.

When carbonic oxide is passed through venous blood it acquires a persistently florid colour, which was first pointed out by Claude Bernard, and the colouring-matter, although it possesses a spectrum identical with that of ordinary blood, is distinguished from it by not yielding, when treated with reducing agents, the spectrum first described by Stokes as that of reduced or purple cruorine. This property of carbonic-oxide blood was first published by Hoppe. As a result of his own investigations, Dr. Gamgee has found:—First, that the peculiar compound of carbonic oxide and blood colouring-matter is formed even when the latter has been reduced, and is still in the presence of a large excess of a reducing solution. Secondly, that when the compound of carbonic oxide and colouring-matter is treated with acetic acid, whilst hæmatine is formed, carbonic oxide is disengaged. Thirdly, that carbonic oxide, besides modifying the optical properties of the colouring-matter of blood, affects in a remarkable manner the point at which it coagulates, so that, under its influence, an almost perfect separation of the hæmotoglobulin (using the term to express the normal colouring-matter of the blood) from the albumen may be effected. Normal ox's-blood, when diluted with nine times its volume of water, becomes turbid at 145° Fahr., and when the temperature has reached 172° Fahr. its colour is completely destroyed. If such a

[illegible] with carbonic oxide, whilst, when the temperature [illegible] the albumen has separated in flakes, the blood corpuscles remain unchanged. It is only when the temperature is raised to 75° C. that the colouring-matter commences to coagulate. The coagulum which is obtained on further heating is of a reddish colour, unlike that of normal blood. Finally, if blood be saturated with CO, and evaporated to dryness at a temperature below that at which the colouring-matter coagulates, the dry residue yields its colouring-matter to water, and the solution presents all the optical properties of carbonic-oxide blood. When the solution is boiled, the compound with the colouring-matter yields carbonic-oxide gas. Fifthly, poisoning by pure carbonic oxide, or by the fumes of charcoal, invariably leads, before death occurs, to those changes which are characteristic of carbonic-oxide blood, being pure vermilion. Sorby's microspectroscope answers admirably for these investigations, and the solution which Dr. Gamgee recommends for this special purpose is one containing tin, in preference either to sulphide of ammonium or protoxide of iron. Sixthly, whilst it results from Dr. Gamgee's researches that no gas or poisonous agent exerts the peculiar action on blood colouring-matter which is produced by CO, it is specially to be noticed that prussic acid and laughing-gas, which have the power of rendering blood florid, do not prevent its being reduced. Thus the question which Claude Bernard suggested some years ago, as to whether prussic acid exerts on blood a similar action to that of carbonic oxide, is answered in the negative.

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*On the Sources of the Fat of the Animal Body.* *By* Drs. J. H. Gilbert, *Ph.D., F.R.S., F.C.S.*, and J. B. Lawes, *F.R.S., F.C.S.**

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*On the Conditions of the Protoplasmic Movements in the Egg of Osseous Fishes.*
*By* Dr. W. H. Ransom.

The author reported the results of experiments upon the eggs of Pike and Sticklebacks, with the view of determining the essential and modifying conditions of the movements seen in their yelks.

He related the effects of various poisons, of increasing or reducing the temperature, of the application of galvanic currents and deprivation of oxygen. The chief conclusion attempted to be drawn was that these movements demand the presence of oxygen in the surrounding medium as an essential condition of their existence.

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*On the Comparative Vitality of the Jewish and Christian Races.*
*By* Dr. Richardson.

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*Physiological Demonstrations of Local Insensibility.* *By* Dr. Richardson.

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*On the Presence of Ammonia and its Homologues in the Blood.*
*By* W. L. Scott.

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*On the Physiological Action of Medicines.*
*By* William Sharp, *M.D., F.R.S., F.G.S.*

The subject of this paper was the action of medicines when taken in *health*.

That drugs ought to be experimented upon by healthy persons was suggested by Haller; the importance of such experiments, and their necessity, was unanimously agreed upon by the Medical Section of the Scientific Congress at Strasburg in 1842. The memorial upon this subject from the British Association last year (Birmingham Meeting, 1865) to the General Medical Council, presented by Prof. Acland, May 17, 1866, was referred to.

Experiments already made by Antony Stoerk (in Vienna) upon himself with aconite, colchicum, &c., from 1742 to 1762; by Samuel Hahnemann with many

* *Vide* Transions of the Sections, p. 41.

drugs, from 1790 to 1810; what is commendable in these experiments, and what is deficient.

Suggestions were made relative to further experiments (1) on the objects to be pursued, (2) on the mode of proceeding, (3) on the utilization of the results.

The paper recommended the investigation of the physiological action of medicines with the view to determine their therapeutic use.

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*On the Movements, Structure, and Sounds of the Heart. By* Dr. SIBSON, *F.R.S.*

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## ANTHROPOLOGY.

### *Address by* A. R. WALLACE, *F.R.G.S., &c.*

ANTHROPOLOGY is the science which contemplates man under all his varied aspects (as an animal, and as a moral and intellectual being) in his relations to lower organisms, to his fellow men, and to the universe. The anthropologist seeks to collect together and systematize the facts and the laws which have been brought to light by all those branches of study which, directly or indirectly, have man for their object. These are very various. The physiologist, for example, studies man as a wondrous and most complicated machine, whose parts and motions, actions and reactions he seeks thoroughly to understand. The comparative anatomist and the zoologist compare his structure with that of other animals, take note of their likenesses and differences, determine their degrees of affinity, and seek after the common plan of their organization and the law of their development. The psychologist studies the mind of man, its mode of action, and its development, compares it with the instincts and the reasoning faculties of the lower animals, and ever aims at the solution of the greatest of problems—whence and what is mind. The historian collects and arranges the facts of man's progress in recent times; the geographer determines the localities of the various races that now inhabit the earth, their manners, customs, and physical characteristics; the archæologist seeks, by studying the remains of man and his works, to supplement written history and to carry back our knowledge of man's physical, mental, and moral condition into prehistoric times; the geologist extends this kind of knowledge to a still earlier epoch, by proving that man coexisted with numerous animals now extinct, and inhabited Europe at so remote a period that the very contour of its surface, the form of its hills and valleys, no less than its climate, vegetation, and geology, were materially different from what they now are, or ever have been during the epoch of authentic history; the philologist devotes himself to the study of human speech, and through it seeks to trace out the chief migrations of nations, and the common origin of many of the races of mankind; and, lastly, the phrenologist and the craniologist have created special sciences out of the study of the human brain and skull. Considering the brain as the organ of the mind, the phrenologist seeks to discover in what way they correspond to each other, and to connect mental peculiarities with the form and dimensions of the brain as indicated by the corresponding form of its bony covering. The craniologist, confining his attention to the skull as an indication of race, endeavours to trace out the affinities of modern and ancient races of men, by the forms and dimensions of their crania. These various studies have hitherto been pursued separately. There has been great division of labour, but no combination of results. Now it is our object as anthropologists to accept the well-ascertained conclusions which have been arrived at by the students of all these various sciences, to search after every new fact which may throw additional light upon any of them, and, as far as we are able, to combine and generalize the whole of the information thus obtained. We cannot, therefore, afford to neglect any facts relating to man, however trivial, unmeaning, or distasteful some of them may appear to us. Each custom, superstition, or belief of savage or of civilized man may guide us towards an explanation of their origin in common tendencies of the human mind. Each peculiarity of form, colour, or constitution may give us a clue to the affinities of an obscure race. The anthropologist must ever bear in mind that, as the object of his study is *man*, nothing pertaining to or cha-

racteristic of man can be unworthy of his attention. It will be only after we have brought together and arranged all the facts and principles which have been established by the various special studies to which I have alluded, that we shall be in a condition to determine the particular lines of investigation most needed to complete our knowledge of man, and may hope ultimately to arrive at some definite conclusions on the great problems which must interest us all—the questions of the origin, the nature, and the destiny of the human race. I would beg you to recollect also that *here* we must treat all these problems as purely questions of science, to be decided solely by facts and by legitimate deductions from facts. We can accept no conclusions as authoritative that have not been thus established. Our sole object is to find out for ourselves what is our true nature, to feel our way cautiously, step by step, into the dark and mysterious past of human history, to study man under every phase and aspect of his present condition, and from the knowledge thus gained to derive (as we cannot fail to do) some assistance in our attempts to govern and improve uncivilized tribes, some guidance in our own national and individual progress.

*Recent Explorations in Chambered Cairns in Caithness.* *By* J. Anderson.

*On the Stature and Bulk of the Irish, and on Degeneration of Race.* *By* Dr. J. Beddoe.

The author had derived his data from the measurement of 1517 recruits of Irish birth, and of 23 years of age and upwards. The average height and weight yielded by his figures were 5 feet 7·25 inches and 138·03 lbs.; these he supposed to represent corrected averages of 5 feet 7·4 inches and 138·5 lbs., allowing for surplusage. The men were measured and weighed naked. The true average stature of the general population, or of that portion of it which supplied recruits, including men of insufficient height for the army, might be conjectured from the culminating point of the numbers at each inch on the scale. It would probably be 5 feet 6·5 inches, or a trifle more, for all Ireland, varying from 5 feet 7·3 inches in the agricultural population of the eastern and southern provinces, to as low as 5 feet 5·5 inches in Connaught. Dr. Beddoe endeavoured to investigate the proportions of the principal race-elements in the several provinces by the aid of an analysis of the surnames; he showed that the degradation of stature, so far as the numbers observed enabled him to decide, was greatest among the Connaught people with Saxon or imported names; and argued the question whether this might be due to the original differences of race, or to the influence of causes of degeneration.

*On Stone Implements of Esquimaux.* *By* Vice-Admiral Sir Edward Belcher.

*On Colonies in South Africa.* *By* W. J. Black.

*On a* Condylus Tertius *occasionally observed in the Skulls of Natives in the Indian Archipelago.* *By* C. Carter Blake, *F.G.S., F.A.S.L.*

The author described the circumstances under which a medial condyle was occasionally developed from the basioccipital bone, and compared the observations of Halbertsma and Barnard Davis. The most striking case he had yet observed was one which was presented by a skull of a Yenadie from Strihureecottah, in Madras. The condylus tertius had here articulated with the odontoid process of the axis vertebra.

*On Skulls from Round Barrows in Dorsetshire.* *By* C. C. Blake, *F.G.S., Curator and Librarian, Anthrop. Soc. Lond.*

The author remarked that they were obtained by Dr. Hunt, the President of the Anthropological Society, from some barrows near Blandford. Dr. Thurnam, in a dissertation on the two principal forms of English and Gaulish skulls, gave a table containing the measurement of twenty-five skulls from the English round barrows.

The longest of Dr. Thurnam's specimens exhibited a cephalic index of ·74, and the shortest ·87, the average being ·81; and Dr. Thurnam therefore concluded that the typical character of the skulls found in round barrows was that which presented the brachycephalic type. When the skulls taken from the Blandford barrows were carefully measured, it appeared that the rate of breadth was much smaller than the average of those measured by Dr. Thurnam. Where Dr. Thurnam's lowest breadth was ·74, the lowest of the Blandford skulls was ·66; and where his highest was ·87, the highest of those from Blandford was ·81, the average being in each case respectively ·81 and ·73. If the Blandford skulls (nine in number) were added to Dr. Thurnam's table of twenty-five, the average of the whole thirty-four would be found to be ·77. The distinction between an average of ·81 and ·77 must strike all observers, and some might consider the deduction of 4 per cent. as invalidating many of the general conclusions arrived at by Dr. Thurnam. If the author were inclined to base any conclusions on his measurements, he might reverse Dr. Thurnam's "sort of axiom," and say "long barrows, long skulls; round barrows, long skulls too, and sometimes longer." A description of the skulls would follow at another time, and the conclusions he would draw at present were as follows:—1st. That the state of materials at disposal precluded any generalization as to the prevalence of a brachycephalic type of the skull in the round barrows of the south of England. 2nd. That a much larger series of skulls from the round, as well as from the long barrows must be measured before any conclusion could be arrived at as to the cranial modulus.

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*On a Human Jaw from the Belgian Bone-Caves.*
*By* C. C. Blake, *F.G.S., Curator and Librarian, A.S.L.*

The jaw was discovered in the Trou de la Naulette, near Dinant, Belgium, by Dr. E. Dupont, acting under the orders of the Belgian Government. It was found in undisturbed sandy clay (*lehm* or *limon fluviatile*) at a depth of 3½ metres (11 ft. 4 ins.), the clay alternating with stalagmite, and affording evidences of gradual deposition. The characters which it presented were very different to those exhibited by the jaws of the white races of the present day, and presented in many points an exaggeration of the characters of the lowest Australian jaws. In some respects it differed widely from the human jaws known to anatomists, and afforded great resemblance to the jaw of the young orang (*Simia morio*). The author gave a careful comparison between this jaw and certain typical jaws selected from three thousand which he had examined, and expressed his belief that the jaw was of vast though unascertained antiquity, and that on the whole the jaw more closely resembled those of the Sclavonic races than any other jaw, while in some points it presented an analogy to and exaggeration of the Australian.

After giving a minute account of the circumstances which led to the investigation of the Belgian caves by the Anthropological Society in conjunction with Dr. Dupont, the author entered into considerable details respecting the number and character of these caves, the various levels and palæontological horizons at which they were found, the characteristic fossils of each, the nature of the human remains, and the geological conditions under which the successive deposits of rolled pebbles, stratified lehm, or *limon fluviatile*, angular pebbles, and loess were found. He concluded:—

1. That the deposit of stratified "lehm" under stalagmite, in the Trou de la Naulette, was due to the action of slowly operating causes.

2. That the individual whose jaw was found therein was contemporary with the elephant and rhinoceros, whose remains are imbedded under like conditions.

3. That some of the characters afforded by the jaw indicate a resemblance to the jaws of the Sclavonic peoples of Eastern Europe, as especially exemplified by the Masures and Wends.

4. That some of the characters of the jaw from the Trou de la Naulette indicate a strong resemblance to, and exaggeration of, the characters afforded by the melanous races of men, and especially the Australian.

5. That the above characters afford a distinction between the remains found in the Trou de la Naulette and the Trou de Frontal, which latter contained the reindeer-period individuals strongly resembling the Calmucks of the present day.

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*On Fishing Indians of Vancouver's Island.* *By* E. B. Bogg.

*On Ancient Engravings on Stone from Southern Peru.* *By* W. Bollaert.

*On Central American Hieroglyphs.* *By* W. Bollaert.

*Researches into the Anthropology of Lower Brittany.* *By* Dr. P. Broca.

*On the People of Andorra.* *By* Dr. R. S. Charnock.

*On the Indians of the Mosquito Territory.* *By* John Collinson.

*On the Power of Rearing Children among Savage Tribes.* *By* S. P. Day.

*On the Anthropology of Caracas.* *By* A. Ernst.

*Notice of a Kjökkenmödding in the Island of Herm.* *By* J. W. Flower.

*On the Land Dayas of Upper Sarawak.* *By* E. P. Haughton.

*On the Cranial Measurements, &c., of Modern Norwegians.*
*By* Dr. J. Hunt, *F.S.A., President A.S.L.*

The cranial measurements of the majority of the cases indicated that the form of the skull in the Norwegians is much rounder than had hitherto been supposed. The average height of seventy-eight cases of males was 5 feet 8 inches. The hair in the majority of cases was light brown, and the eyes light blue. The author contended that there was no such thing as a Norse race, the races inhabiting that country differing quite as much, if not more, than any inhabiting this country. The author gave some details of his examination of Swedes and Lapps, and concluded by urging the desirability of not confusing the inhabitants of Norway and Sweden.

*On the Principle of Natural Selection applied to Anthropology, in Reply to Views propounded by some of Mr. Darwin's Disciples.* *By* Dr. J. Hunt, *F.A.S., President A.S.L.*

*Remarks on two Extreme Forms of Human Crania.*
*By* Professor Huxley, *F.R.S., F.G.S.*

One of these skulls, that of a Tartar, was exceedingly round, being nearly equal in breadth and length (977 : 1000). The other was probably that of an Australian or Negrito, and represented the very extreme of the narrow type of skull, the cephalic index, or proportion of breadth to length, being one of the smallest on record (629 : 1000). Professor Huxley then proceeded to show how far the relative characters of these skulls might be lost sight of in the ordinary method of measurement. He insisted on the necessity of due care being taken to compare sections of skulls by super-position of the basi-cranial axes.

*On the Indians of the Paraná.* *By* Consul T. J. Hutchinson.

A Slate Armlet was exhibited by A. H. W. Ingram.

*On the Saracens in France.* *By* M. G. Lagneau.

*On Papers from Lahore.* *By* Prof. Leitner.

*On the Mental and Moral Characteristics of the Zulu Kafirs of Natal.*
*By* Dr. Robert Mann, *F.R.A.S.*

*On Human Remains from Poole's Cavern.* *By* J. PLANT.

*On the Habits and Manners of the Marvar Tribes of India.* *By* Dr. J. SHORTT.

*On Phenomena of the Higher Civilization traceable to a Rudimental Origin among Savage Tribes.* *By* EDWARD B. TYLOR.

The value of investigations among savage tribes, as affording explanations of many opinions and customs prevalent among the higher races, is, in the opinion of the writer of this paper, only beginning to become fully apparent. His object was, accordingly, to give examples of the province and method of such investigations. Comparative mythology being one of the best-known fields in which this kind of research has been carried on, it was shown by examples quoted from Polynesia that the myth-producing state of mind is there to be studied in actual existence among modern savages. Not only may the sources of mythology in general be thus explored, but even myths occurring in an isolated and unintelligible shape among the higher races may be shown to be fragments of consistent and intelligible mythic conceptions still existing among savage tribes. Thus the story of the opening and shutting rocks of the Symplegades, through which the ship Argo passed by the aid of Athene, was compared with a New-Zealand myth, in which the Night is conceived as a monstrous creature whose jaws are to be seen opening and shutting on the evening horizon, and into whose stony mouth the Sun-god Maui enters and perishes. A similar account to this is found in the mythology of the Karens of Burmah, where two strata of rocks are described which open and shut, and between which the sun enters at sunset.

Again, the ceremony of sacrificing animals, food, clothes, &c., especially to the souls of the dead, as found among races in a comparatively high state of culture, was instanced as having come down as an inherited custom from an earlier mental condition, in which an evident and practical purpose belonged to it. Among the lower races, the opinion is evidently found that not only men and beasts, but trees and corn, and even inanimate objects, such as boats and weapons, have each something of the nature of a spirit or soul,—generally a shadowy resemblance of the material body. In the offerings made to the dead, not only are wives, slaves, and animals put to death, that their souls may serve the soul of the deceased in a future state, but food, clothes, arms, ornaments, &c., are buried, burned, or exposed, that their spirits may be despatched for his benefit. When such sacrifices are made to gods, elves, and other spiritual beings, there is considerable evidence of a similar intention of presenting the spirit of the offering to the being worshiped. A number of details were brought forward to illustrate this opinion as prevalent among the lower tribes, and furnishing a satisfactory cause for ceremonies inherited and practised with a changed meaning by higher races.

In a similar manner the practice of ceremonial fasting was discussed as belonging originally to the lower races, and handed down with much change of meaning among more cultured peoples. The subject of magic was then introduced, to show that the arts of divination and sorcery are, when found among the higher races, mere relics of practices which are perfectly intelligible under, and consistently belong to, the mental condition of the savage. Thus the ordeal of the suspended Bible and key was compared with such similar practices as that of divining by a suspended sickle among the Khonds of Orissa. In conclusion, the author spoke of the aid which may be rendered by the study of lower phases of civilization, in the problem of separating among civilized men the results of inherited opinion from those of scientific inquiry.

*Antiquity of Man in relation to Comparative Geology.* *By* C. S. WAKE.

*Notes on Madagascar.* *By* T. WILKINSON.

## GEOGRAPHY AND ETHNOLOGY.

*Address by* Sir CHARLES NICHOLSON, *Bart., LL.D., President of the Section.*

IN opening the business of this Section the President passed in review the recent acquisitions and speculations in the sciences of Geography and Ethnology. Geography, he said, in the restricted sense in which it is now used, was chiefly confined, in its scope, to inquiries as to the leading features of the earth's physiognomy, without dealing with those special causes and remoter influences to which all the great phenomena of the surface of the globe were referable. This circumscription, and yet indefiniteness, of aim was not, however, peculiar to the subject we had to deal with; it belonged to every other department of human knowledge, the bounds of which are more or less arbitrary, each being but a part of one great whole, each separated from the other by faint and often invisible lines, reciprocally melting into each other. The same remark applied to ethnology, the indefiniteness of the name having become a source of difficulty. A fastidious criticism might find equal objection to the employment of such terms as ethnography, zoography, anthropology, biology, and others. Many of these terms are sufficiently elastic not only to include man in all his objective relations (in which anatomy and physiology, human as well as comparative, could be embraced), but all the ethical and moral qualities of his nature would become alike objects of contemplation and research. Facts are, after all, the ultimate aim of all inquiry, and it was of little consequence with what special machinery or under what particular designation they might be gathered together. In reviewing the recent progress of geographical research, he alluded to the discovery of the Lake Albert Nyanza by Sir Samuel Baker, and described the nature of the problem which now remained to be solved in the geography of this part of Africa. This was the connexion or separation of the two great inland seas, the Tanganyika and the Albert Nyanza. The difference of level between them (800 feet) militated against the supposition of their union; but a doubt existed as to the correctness of the levels given in the case of the Tanganyika, the measurement having been made by Burton and Speke with a single and very imperfect instrument. It was hoped that this point might be settled by Livingstone, the last news from whom informed us of his arrival at the mouth of the Rovuma river on the east coast, whence he was about to travel by land into the interior. The road to the great southern lake, Nyassa, was reported to be open, and towards it this distinguished and intrepid traveller was, in all probability, now on his march. In other parts of Africa, the expeditions of the Baron von der Decken and M. Du Chaillu were mentioned, and he announced to the meeting that the latter traveller would communicate a paper to the Section embodying his principal observations on the physical geography and tribes of the new region he had traversed in his last journey. In Asia several very important geographical expeditions had recently been undertaken. Two of these were in connexion with the great trigonometrical survey of India now in course of execution. To Capt. Montgomerie, who had been charged with the survey of Cashmere and the North-western Himalayas, we were indebted for one of these Central Asian explorations; the other was undertaken by Mr. W. H. Johnson, a civil assistant in the survey. This gentleman, having carried the survey to the summit of the Karakorum Pass, the extreme limit of the territory under British influence, had been there invited by the chief of Khotan, in Chinese Tartary, to visit his dominions. Mr. Johnson had boldly undertaken the journey over the as yet unknown plateau stretching between the Himalayan and Kuen Lun ranges, and reached Ilchi, the capital of Khosan. The plateau was surveyed, and the position of Ilchi accurately determined. The vast plains of Central and Western Asia still presented, however, innumerable features deserving of minute investigation. Amongst these was the problem of the alleged ancient course of the Oxus into the Caspian Sea, instead of the Aral, as at present. In South-eastern Asia, a young man, Mr. J. Thomson, had recently returned from a successful enterprise in Cambodia. Mr. Thomson had been excited by the account which the late Mr. Mouhot had given of the splendour of the ruins of ancient temples buried in the tropical forests of that country, and had resolved, alone and unaided, to visit them, and bring away photographs and plans of these structures. He had returned, and brought with him a

very large series of pictures of great beauty, which would be exhibited to the Section. The useful labours of the Palestine Exploration Fund were next noticed, and afterwards the minute and accurate surveys made by Mr. W. Chandless on the river Purus, in South America, and also the recent expedition into the interior of Australia undertaken for the purpose of discovering remains of the unfortunate Leichhardt expedition. This search, so munificently supported by several of the Australian governments and by Her Majesty the Queen, had not yet accomplished much. A severe drought had impeded the progress of the searching party; but they had succeeded in traversing the continent to the banks of the Flinders river, and examined the trees on which the L's were cut at a spot which was supposed to be the last halting-place of the lost explorers. Now that settlements are formed along the whole east coast of Australia, at short distances from each other, it was very desirable that exact registers should be established at various points, so as to determine whether there be any appreciable change in the relative levels of land and water along the coast, and thus throw light on an interesting question in physical geography, namely, the gradual subsidence of the Pacific coasts of Australia. After noticing the great extent of unknown land, especially in Africa and New Guinea, yet remaining to be explored, the President concluded by a review of the recent great strides made in the science of ethnology since the discovery of stone implements in the alluvial deposits of St. Acheul. We here see the widest field opening for speculation and inquiry. There was a tendency with many ethnologists in their inquiries to disparage the force of the evidence afforded by language as a key to the history and the relationship of the different sections of mankind to each other. Yet it was impossible to gainsay the absolute correlation that exists between certain organic forms of speech and some of the great typical divisions of man. Language, in his opinion, constitutes one of the most permanent and indelible tests of race, and no system of ethnology could dispense with the aid of philology. The early utterances of man have become stamped with a certain degree of immortality. The Celtic and the Hindoo, the early Persian, the Hellenic and Latin races betray the community of their origin in the dialectic affinities of the tongues they speak. On the banks of the Tigris and the Euphrates the Arab employs a language which is the lineal descendant, with few fundamental changes, of that spoken by his forefathers in the days of the Hebrew patriarchs; whilst in the Semitic names scattered along the shores of the Mediterranean Sea and eastern coast of Africa, we have unerring indications of the progress and settlements of early Semitic tribes. However plastic and evanescent, under certain local conditions, characteristic forms of speech may be, they still afford, in the history of man, the key to many of the vicissitudes that have marked his migrations, his conquests, his religion, his social polity, the measure of many of the attributes by which as an individual or a race he is distinguished from his fellow men.

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*On the Physical Geography of the Eastern Part of the Crimea and the Peninsula of Taman.* *By* Prof. ANSTED, *F.R.S.*

The peninsula of Taman stretches out west beyond the whole range of the Caucasus; but it would only be a delta of the Kuban were it not for the very remarkable phenomena due to recent volcanic agency which it exhibits. These consist of a series of conical hills of mud, ranging for many miles, and connecting the volcanic district of Tiflis with the Putrid Sea, which constantly emits sulphurous fumes. The physical condition of this part of Europe is quite exceptional, the phenomena extending for a distance of 1000 miles. The conical hills of Taman are about 250 feet high, and extend for about thirty miles. There is a constant shifting of the actual points of eruption. The physical geography of the north-eastern shores of the Black Sea and its dependencies is certainly modified by these curious phenomena. They produce hills where we should otherwise have a dead flat, and the land is for the most part barren and unprofitable. Continuous but very slow subterranean action along this line is consistent with what we know concerning the axis of elevation that has for a very long geological period affected the land of the eastern hemisphere. All that part of the world has been elevated, and parts of it have been depressed in the later periods. The great plains of Europe and Asia were covered by the sea during a time comparatively recent, and the elevation has

been on a line parallel with that of the mud-volcanoes and eruption of hydrocarbon vapours and fluids.

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*On the District of Lake Pangong, in Tibet.* *By* Capt. H. H. Godwin-Austen, *F.G.S., F.R.G.S., Assistant in the Trigonometrical Survey of India.*

The author left Leh to survey the shores of Lake Pangong in July 1863. North of the Indus, from its junction with the Dras river, lies a high range of mountains, which separates the Indus drainage from that of the Shayok or Nubra. The passes over this range are of great elevation; on the direct road from Leh to the Pangong lake there are two, viz. the Chang La, 17,470 feet, and the Kay La, 18,250 feet above the sea-level. Having crossed the Chang La to the village of Tanksé, the surveying party proceeded along the valley leading to the western extremity of the lake. The stream which flows down the valley contains but little water. If the waters of the Pangong (which have now no exit) should reach the altitude they formerly attained, they would force a passage across this barrier.

A Trigonometrical station of the Indian Survey lies close to the water's edge, its height being 13,931 feet above the sea-level. The waters are of an intense blue colour, clear as crystal, but too saline to be drinkable. The author commenced his march along the southern shores on the 22nd of July. He pursued this route until he came to a point where the lake contracts to very narrow dimensions; he then crossed to the northern shore, and reached to within a short distance of Noh, a Chinese town of the province of Rudok, where he was compelled to turn back, owing to the entreaties of the governor. Beyond, the lake again expands for a long distance; it then again narrows, and further east again expands into a fine sheet of water, the termination of which is unknown. The first, or lower lake, is 40 miles in length, the second 33 miles, and the upper, or easterly portion, at least 18 miles.

Captain Godwin-Austen showed that the waters of this remarkable lake must formerly have been fresh, and must have attained a much greater elevation than they do at the present time. At present the waters are too salt to nourish a single molluscous animal. The lower lake does not contain in its waters or on its banks a vestige of any kind of plant, although formerly there must have been a considerable vegetation to sustain so much animal life. There are signs of the climate of the region having been formerly much more humid than it is now. The absence of streams whose waters find an exit in it is a curious feature; but there are numerous lateral valleys leading up towards the glaciers of the surrounding mountains, and the bottoms of the valleys near the lake are composed of beds of silt containing fossil shells, showing that considerable streams, bringing down detritus from the mountains, must formerly have flowed down them.

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*On the probable Lower Course of the Limpopo River, South-east Africa.* *By* Thomas Baines, *F.R.G.S.*

Captain Cornwallis Harris, who reached the sources of this river in 1836 and 1837, considered it identical with the Manice, or King George River flowing into Delagoa Bay.

About this time the great emigration of Dutch-African farmers was going on from the Cape Colony northward, and though they did not then take possession of the country now known as the Transvaal, many of them penetrated the country of the Limpopo, and defended themselves desperately against the attacks of the savage Matabili.

In 1850 I visited the country of the Transvaal emigrants with Mr. Joseph Macabe, but their independence not having then been acknowledged by our government, they prevented our passing to the interior, and fined my friend for having published a short itinerary in a frontier paper.

From information supplied me by Macabe and several Dutch hunters, I drew a map of the upper Limpopo and its tributaries, and a very intelligent German, named Coqui, who had travelled from Origstadt, in the Transvaal, to Delagoa Bay, drew me a sketch-map of his route, which I added to that I had already made.

The "Oori or Krokodil Rivier," the main branch of the Limpopo, and the Lipel-

lulah or "Olifant's Rivier," pass on the west and north of the town of Origstadt, and appear to join after passing down the Drakensberg, which, rising near Natal, stretches parallel with the coast far to the north, and is in fact the sea face of the great interior plateau (which, however, where the Limpopo rises is broken into rugged hills, instead of showing the dead level in which the Okovango rises near the west coast).

The descent of the Drakensberg occupied an entire day; and the country between it and the sea was level, sprinkled with bush and forest, and abounding with game. He crossed the Manice, the Omquinie, and the Tamatie, all of which rise in the Drakensberg, and are not connected with the Limpopo, and which at their junction form a large sluggish sheet of water, probably the same seen by Louis Triechard about twenty years before. Canoes were used by the natives; and the great slave-dealing Chief Mannekos held the country to the east. The Mattol, a broad, sluggish, marshy river, was crossed above where it falls into the bay, and the waggons halted on the beach opposite a tongue of sand with about twenty huts, constituting the village of Lorenzo Marques, which is isolated at high water.

To the east of this was the Manice, with 8 fathoms at its mouth, and 2 at forty miles up, where the smaller slave schooners went to receive their cargoes. All the party, except Mr. Coqui, died of fever and fatigue during the return journey; the messengers sent with letters perished on the route; only one reached his destination, and two young farmers with fresh oxen came immediately from Origstadt, and were fortunately in time to rescue Mr. Coqui.

Mr. Gassiott, who travelled in 1851–52, heard that the Limpopo and Elephant rivers, after joining, flowed to Inhambane.

Mr. J. Chapman told me that his partner Edwards, visiting Moselekatse, asked particularly about the mouth of the Limpopo, and was told that lower down it was called Saabē, and the direction in which the Matabili pointed corresponds exactly with the position of Sabia. Chapman considered the information thus obtained to be thoroughly trustworthy; and I may add that when I have tested the knowledge of the natives, even in the dark, I have found some of them point out the direction of distant places as accurately as I could set them with a pocket compass.

While I was in the Transvaal I was told of natives to the north who retained many Mahometan customs, and also of ancient buildings of stone in ruins.

These are mentioned in the early Portuguese records, which attribute them to the Queen of Sheba; and about 1854 or 1855 two gentlemen of the Rhenish Mission Society obtained leave to visit them, but were deterred by the prevalence of small-pox. The natives described to them pyramids, subterranean galleries, sphynxes, and hieroglyphic inscriptions; and whatever be the character of these ruins, there is no doubt but they are worthy of careful investigation.

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## *The Zambesi and its probable Westernmost Source.*

*By* Thomas Baines, *F.R.G.S.*

The Zambesi flowing into the Indian Ocean, in latitude between 18° and 19° south, drains nearly all that part of Africa lying between the parallels of 10° and 20°. During nearly half its course from the western side of the elevated plateau of the interior it is a broad surface river, in which open reaches navigable for many miles alternate with extensive swamps so choked with reeds, rising from 10 or 15 feet below the water to an equal height above, that it is difficult to force a canoe through them. Nearly in the centre of the continent (lat. 17° 55′ 4″ S., long. approximate 25° 47′ E.), where the river is 1900 yards in breadth, a tremendous chasm, rifted right across it, engulphs the water 400 feet into the earth, and forms the mighty cataract called the Mosi-o-a-tunya (smoke-sounding), or Victoria Falls; the width of this chasm is from 75 to 130 yards, and the spray cloud (by approximate measurement) rises 1200 feet, showing under the tropic sun a rainbow of surpassing brilliancy, and keeping ever wet the dense forests on the verge. A little more than two-thirds from the western end the dark portals of the outlet allow the water, now compressed into a deep green stream, to escape through a prolongation of the chasm, winding and redoubling abruptly for many miles, opening into long navigable reaches, or closing in narrow mountain-gorges.

The rock seems split from the centre to the sea, a distance of 800 miles, by some convulsion of nature, the resemblance of the gorges of Lupata and Kebrabasa to

those at Swamanes and Logier Hill, lat. 18° 4 56' S., long. approx. 26° 38' E., leaving no doubt that they were formed by the same cause. Most of the surface rocks seem igneous. Slight earthquakes are common in Damara Land, and cattle graze in a supposed extinct volcano in Namaqua Land.

It is not my intention to speak now of the northern branches of the Zambesi, but only of the westernmost, and of the means by which it might be made available for the exploration of the great river.

Since 1824 it has been known that the Cunene, or Nourse River, reached the Atlantic in lat. 17° S.: it was supposed to rise in the centre of the continent, and the Makuru Makovanga was connected with it on the maps of Messrs. Galton and C. J. Andersson in 1851 and 1853. In 1859 Mr. Andersson reached the Okovango in 17° 30' S., and long. approx. 19° E.: it was a noble stream flowing *not to the west, but to the east*, and he naturally concluded it must be the Chobe, or that branch of the Zambesi which is called so. He descended forty miles in canoes to the Chief Chinungo, and again saw the river a degree above his first point, or lat. 17° 46' S., long. 19° E., when, worn out by fever, he was relieved by Mr. Fred. Green.

A native tracing a map on the ground made the river give off at Libebe's Island a smaller stream called the Teoughe, which flowed south-east to Lake Ngami, while the main one continued east to Sekeletu's Town, at Linyanti. In confirmation of this, it was said that the Makololo had come up all the way in canoes from Linyanti to Libebe's, and had carried off vast herds of cattle and many slaves.

Mr. Green, Wilson, Lindholm, and others agree in the belief that the Okovango, rising near the west coast, gives only a small part of its waters to the Teoughe, while the main stream flows east as one of the principal branches of the Zambesi.

Mr. Green, accompanied by his wife, has at length succeeded in penetrating from Damara Land to the Cunene, and appears to think that the two rivers have their sources in the same extensive marshy tableland, the Okovango flowing blue and clear toward the east, while the Cunene, turbid with the soil, glides between overhanging trees, or rushes down the Atlantic face of the plateau.

If the traveller enters the Portuguese country north of the Cunene he may hire native porters with calico and blue Selampore; the American yard-wide calico is much prized, as two widths of a fathom each make a six-foot wrapper; our own stout double width unbleached beats it out of the market, but narrow stuff is of little value. It is necessary he should show himself independent of native help, that he may obtain it more readily: and for this purpose the boxes in which he carries his goods ought to be of uniform size, and taper so that he may put them together as a skiff. Copper is the best material. Tin rusts, and wood is eaten by ants. I have used a light frame of reeds covered with two thicknesses of oiled calico; this may be made in a day or two, and with care is effective enough.

If he starts from Damara Land, one ox waggon will carry more than an army of natives; the waggon chests may be of uniform size and water-tight, the side chests being tapered to make the bow and stern. The waggon tilt might be convertible into a boat, or the sides and bottom might be of unshaped planks to build one.

I should prefer sheets of copper 4 feet by 2 feet, 1 lb. to the foot, eighteen of which would build a boat 20 feet long, and 4 feet beam. If put together with screws and nuts it might be taken to pieces at the portages, and rebuilt beyond them. I should build one which might be used as a single boat in the narrows, or a double canoe with a commodious deck in the broad rivers.

If the traveller wished to preserve his waggon, the heavy parts might be rafted with reeds; but at the Victoria Falls he would probably meet some colonial traveller or trader willing to assist in carrying his boat to Logier Hill. I think a whale boat or Norway yawl could pass down Kebrabasa in the flooded season; but if not, the Portuguese settlements on the east coast would be within an easy march, and journals or other valuables might be removed by native porters.

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*On the Relations of the Abyssinian Tributaries of the Nile and the Equatorial Lakes to the Inundations of Egypt.* *By* Sir S. W. Baker.

The author commenced by giving a description of the ancient mystery of the Nile and the long-continued doubt and speculations as to the source of the annual inunda-

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tions and river deposit which caused the fertility of Egypt. He then gave in the form of a brief narrative of his own explorations, first of the Abyssinian tributaries and then of the lakes at the head of the White Nile, an account of the two separate sources, first, of the inundations and fertilizing mud, and, secondly, of the perennial flow of water which prevented the Lower Nile from becoming annually dry when the inundation ceased. His exploration of the Atbara and Blue Nile, in 1861, was undertaken mainly for the purpose of investigating their relations to the main stream. The attempts of the ancient Egyptians, and afterwards of Nero's centurions, to ascend to the sources of the Nile all failed; the latter ascended to a point where the White Nile expanded into vast marshes in about 9° N. lat. No other expedition went so far, until the one under St. Arnaud, despatched by the Viceroy Mehemet Ali, one result of which was the establishment of the trading settlement of Gondokoro, the starting-point of his own expedition to the great Lakes. When he reached the Atbara, from Cairo, on the 13th of June 1861, he found the broad and deep bed of the river almost entirely dry. He looked in vain for a river, but not a drop of water flowed from it into the Nile. Ascending for 180 miles to Gozerajup, he witnessed, on the 23rd of June, the sudden on-coming of the flood caused by the heavy rainfall of Abyssinia at the commencement of the wet season. In a few minutes the Atbara was no longer a desert, but a noble river, 20 feet deep and 500 yards wide. Further up, at Goorassé, he reached the country whence the Atbara derives the vast amount of rich soil which it carries down towards Egypt. The waters were of the consistency of soup. He crossed in succession a number of its tributaries, and found the general trend of the drainage from S.E. to N.W. The Settite, or Taccazzy, is the principal tributary, and brings down almost the entire drainage of Eastern Abyssinia. It has the same character as the Atbara, with the exception that it does not become dry in the dry season. After being delayed for many weeks by the heavy rains, he resumed his journey, and, descending by the banks of the Blue Nile, reached Khartum on the 11th of June 1862, having been just twelve months on the journey. The full significance of the fluvial phenomena which he had observed on this expedition he did not appreciate until he arrived in the region of the great lakes near the equator, which he now prepared to visit. On sailing up the White Nile he found a complete contrast to the rivers which descend from Abyssinia. For forty-five days he struggled through the almost boundless swamps through which it flows. He passed the point at which Nero's centurions had turned back, and the thought came to his mind that what the Romans had failed to do might perhaps be accomplished by Englishmen. At length the elevated land on which Gondokoro is situated was reached, and from thence, with great difficulty, and after many perils, the narrative of which he had already presented to the public, he reached the shores of the great lake. The result of his examination was to prove that the main river of the Nile makes its exit in a perennial stream from the Albert Nyanza, and that the river discovered by Speke, and flowing from the Victoria Nyanza, was a tributary, discharging its waters into the Albert, and following the same course as all the eastern affluents of the Nile, namely, from S.E. to N.W. With regard to the disputed question of the sources of the Nile, we ought to speak comparatively, and not look to the ultimate spring whence the remotest tributary of such a lake flowed, but accept this great reservoir as the true source. He believed geographers were in error in denying that a lake could be a source. He believed that no geographer in England or on the continent now refused his assent to the statement that the White Nile flowed out of the Albert Nyanza. The continuity of the river discovered by Speke and Grant, now called the Victoria Nile, was also now accepted as a fact. He believed that there was no connexion between the Tanganyika and the Albert Lake, but that the watershed of the drainage to the south and north lies between the two. The fullest credence might be given to the altitudes which he had given, as they were made by Casella's thermometers, proved at Kew before leaving England, and again proved after his return. Now the relation of the White Nile to the fertility of Egypt was this: Egypt would be utterly annihilated if it depended for its irrigation on the Abyssinian rivers. These simply cause the annual inundations, and are full only three months in the year, corresponding with the three months' rainfall in Abys-

sinia, from June to September. The supply of water from the great White Nile lakes is constant, for they are fed by a ten months' rainfall over the high lands near the equator. It is this ready flow which prevents Egypt from becoming a desert, and it is great enough to overcome the great absorption in the extensive sandy regions which intervene. When no rain falls in Abyssinia, the supply from the lakes keeps up the flow of the Nile until the rainy season comes round again. On the other hand, the fertilizing soil which annually overspreads the Delta is due exclusively to the rich sediment brought down by the Abyssinian tributaries.

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*Observations on the Character of the Negro Tribes of Central Africa.*
*By* Sir SAMUEL BAKER.

In this discourse the author passed in review the various tribes he had visited on his journey to the region of the Equatorial Lakes of the Nile, and in a series of sketches illustrated the principle that the character of the tribes depended on the physical conditions and productions of the locality they inhabited. He said that true negroes commenced, in ascending from Egypt, at 15° north latitude. The first tribes he met with were those inhabiting the region of morasses extending on each side the White Nile to about 5° N. lat. These were the lowest, both in corporeal condition and moral character. Their forms were emaciated and filthy; they went without clothing, had no religion, and their cookery consisted in grinding the bones of animals between stones to make soup of. No iron ore was found in this region, and consequently they were deprived of the great civilizing advantages attendant on the art of working this metal. Other tribes further south who practise this art have been helped by it to attain a considerable degree of culture. The iron weapons of the Latooka tribe are of exquisite workmanship, and the Unyoro people have even invented a kind of hoe, which Europeans might imitate to their advantage. All the tribes who are thus favoured live in the elevated lands near the equator, and the iron-dust which supplies them with the metal is found in the mountains. The presence of the Tsetse fly has a remarkable indirect influence on the civilization of the tribes. This fly is most capricious in its distribution—present in one area of the country and absent from another. Wherever it is present no cattle can be kept; consequently the natives are deprived of this civilizing influence, for the possession of cattle elevates the character of a tribe in various ways; it promotes industry, ensures a supply of nourishing food, and, by the necessity of defending the herds against all comers, developes a warlike spirit and organization. The Unyoro people, under the influence of these local advantages, have become the most advanced nation in Central Africa; they are well clothed and clean in their persons, courteous and dignified in demeanour, and susceptible of enlarged political organization. The speaker pointed out, in a clear manner, the way in which the tribes of Central Africa may be brought under the influence of European civilization and into an intercourse which would be beneficial both to us and to them. He showed that formerly a considerable trade existed between the east coast and the Equatorial Lakes, and that the line of trade extended south and north along their shores. Ptolemy was indebted for his knowledge of these lakes to the traders of his time. A trade with Europe might be developed along this line; but before any beneficial intercourse can be commenced the internal slave-trade must be extinguished. He gave his view of the negro character in general, and stated, as his conviction, that it was improveable only under the wise and considerate guidance of the white man. Commerce, properly conducted, would ultimately civilize the negroes of these rich countries of Central Africa.

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*On the Lake Kura of Arabian Geographers and Cartographers.*
*By* CHARLES T. BEKE, *Ph.D., F.S.A., F.R.G.S.*

In Lelewel's 'Géographie du Moyen Age,' there is a map, said to be taken from an Arabian work A.D. 883, in which a lake, named Kura-Kavar, giving rise to the Nile, is found situated on the equator. This has been adduced as a proof that the Arabians 1000 years ago possessed a more accurate knowledge of the upper waters of the Nile than geographers of the present century previously to the recent disco-

veries. The author argued that Lake Kura does not represent the equatorial waters discovered by Burton, Speke, and Baker, but the lakes or marshes in about 9° north latitude, at the junction of the Bahr el Ghazál with the Bahr el Abyad, known as Lakes No, Nu, or Berket el Ghazál. Ancient geographers placed much too far south all the lakes connected with the Nile of which they had heard, their error being caused by an incorrect computation of itineraries or estimate of distances. Lake Kura, or No, was described by the author in 1846, in his paper on "The Nile and its Tributaries," printed in the 'Journal of the Royal Geographical Society,' vol. xvii. p. 67. It is also laid down in the map of the basin of the Nile (1859) accompanying his work, 'The Sources of the Nile,' published in 1860.

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*On the Possibility of Turning the Waters of the Nile into the Red Sea.*
*By* CHARLES T. BEKE, *Ph.D., F.S.A., F.R.G.S.*

It too often happens that a tradition which is founded on fact is so misunderstood and misrepresented by commentators, as to assume a character totally at variance with the truth, and thus eventually to be regarded as a mere fable. The separation of the original history from the commentary would at once prove its fabulous character to have been derived from the latter; but in many cases so intimately have the two become incorporated that it is difficult, if not impossible, to distinguish rightly between them.

The author referred to his work 'Origines Biblicæ' as showing how extensively an erroneous construction was put on points of Biblical geography and history by early translators and commentators; and he now adduced a remarkable instance of the like process with respect to the tradition that the rulers of Ethiopia possessed, and had at times exercised, the power to prevent the waters of the Nile from flowing down into Egypt and fertilizing its lands.

The Egyptian historian, George Elmacin, in the 13th century, records that the Nile having failed in the time of Michael, Patriarch of Alexandria (A.D. 1092–95), he was sent by Mustansir Billah, Khalif of Egypt, on a mission to the King of Habesh, who at his instance caused the dam that had been constructed to be removed, so that in one night the Nile rose three cubits, and the fields of Egypt were in consequence watered and sown.

In confirmation of this is the statement of the Emperor John Cantacuzene, in the 15th century. And further, in the beginning of the following century, Albuquerque, Viceroy of India, applied to Emanuel, King of Portugal, for labourers to be sent from the Island of Madeira, who were practised in digging canals, in order that they might turn the course of the Nile towards the Red Sea. That in the opinion of the native Abessinians they always possessed the power to do so, is evidenced by the representations made to the learned Job Ludolf in the 17th century by his Abessinian friend, Abba Gregorius.

All these authorities point to the low countries lying to the north of Abessinia as the general position of the scene of operations. In opposition to them is the circumstantial statement of the traveller Bruce, that about the year 1200, Lalibala, King of Abessinia, intersected and carried into the Indian Ocean two large rivers, which have ever since flowed that way, and that, had he lived, he would have carried a level to Lake Zuwái, in the south of Shoa, where many rivers empty themselves. Dr. Beke adduced conclusive proofs of the entire groundlessness of this statement; which, however, is made so circumstantially and authoritatively as to have caused the two secondary ideas of King Lalibala and Lake Zuwái to be blended with the primary one, so that subsequent travellers and writers have treated the subject as if they were integral portions of the original tradition.

Considering the tradition in its original form, unincumbered by any notions respecting King Lalibala and Lake Zuwái, Dr. Beke pointed out that the dominions of the early sovereigns of Ethiopia extended in a northerly direction, probably as far as 18° N. lat., where they bordered on the territories of the Sultans of Egypt; and he showed that it was to the ruler of this low and level country that the patriarch Michael was sent.

The river flowing through the dominions of this sovereign was neither the main stream of the Nile nor yet its principal Abessinian branch, the Astapus, Blue River,

or Abai; but, on the contrary, the Tákkazye or Setit, of which the lower portion is the Atbara or Astaboras. This is established by the Ethiopian version of the Scriptures, and by the Adulitic inscription of Cosmas Indicopleustes, in which the two names are synonymous; so that the Atbara or Tákkazye was *the* river,—the Nile of the tradition.

From the description given of this river by several modern travellers, especially M. Linant, it appears that the Atbara is called Bahr el Aswad, or Black River, from the quantity of black earth brought down by it during the rains, which is so great as to discolour the main stream of the Nile; it is this branch which is the best source of irrigation, as it contributes most of the slime that manures the lands in Egypt; that it might easily be turned into the Red Sea near Suwákin; and that, in fact, the remains of a bed or canal, already traced by human hands, exist from the Atbara to the Red Sea.

The paper of which the foregoing is an abstract was written by Dr. Beke for the Meeting of the British Association at Ipswich, in 1851. But, reflecting on the importance of the subject, he decided on first submitting it to the late Viscount Palmerston, by whom it was not returned till that Meeting was over; and the author had not cared to avail himself of any other opportunity until now, when he possessed the means of establishing the correctness of his former opinions.

In 1856, when preparing for the press his work, 'The Sources of the Nile,' published in 1860, Dr. Beke identified the position of the city of Ptolemais Theron, founded on the western coast of the Red Sea in the reign of Ptolemy Philadelphus, the identification having been made by the simple comparison of two descriptions of the spot given at an interval of 2000 years, the one by the Greek geographer Artemidorus, and the other by Captains Moresby and Elwon, of the Indian Navy. This identification led to the appreciation of the truth of the further statement of Artemidorus, that, in the neighbourhood of Ptolemais, a branch of the Astaboras discharged itself into the Red Sea, which branch had its source in a lake, and emptied part of its waters here, but the larger portion went to the Nile.

This "branch of the Astaboras" Dr. Beke identified with the Khor el Gash, the lower course of the river Mareb of Abessinia, whose waters in the rainy season spread themselves over the district of Taka, which then resembles a lake, and thence discharge themselves by two outlets, the one going towards the Atbara, and the other towards the Red Sea, near Suwákin.

That this is the case as regards the latter outlet is now established as a fact by the investigations of Dr. Schweinfürth, who in April 1865 travelled from Suwákin to Taka, and states that the Gash is a tributary to, or synonymous with, the Wady Langeb, which is laid down by him as running northwards to Tokár, near Suwákin, where Dr. Beke had approximatively laid down this "branch of the Astaboras" on the authority of Artemidorus.

To show how the waters of the Atbara or Astaboras might be turned into the Khorel Gash, and so made to flow towards the Red Sea instead of down the main stream of the Nile to Egypt, the author cited M. Ferdinand Werne's narrative of an attempt made in 1840 by Ahmed Pasha, governor of Sennár, to turn the waters of the Gash into the Atbara; and though the attempt was frustrated by the natives, the particulars recorded prove the practicability of the undertaking. But if the Gash may be turned into the Atbara by means of a mere dam and canal, the converse must in like manner be practicable; that is to say, the waters of the Atbara might, by similar means, be turned into the Gash, and so made to run towards the Red Sea, to which the fall is 1200 feet or more.

Thus the main stream of the Nile being deprived of so great a bulk of its waters, and especially of that portion of them which contains the fertilizing principle, the dire results recorded in history could not fail to ensue.

In conclusion, the author adverted to the not improbable rise of a great Ethiopian empire, having the power to subject Egypt by the possession of the country through which the Ethiopian Nile flows, even more readily than by the force of arms; and he pointed out the important relation which the solution of this geographical question of the diverting of the waters of this river bears, not merely to the material prosperity, but also to the political and even the social existence of a country, which plays so important a part both in ancient and modern history, and

which is daily rising in importance from her commanding position on the direct high road between the western and eastern hemispheres.

### *On the Eruption at Santorin, and its Present Condition.* *By* Commander Lindsay Brine, *R.N.*

### *On the Physical Geography and Tribes of Western Equatorial Africa.* *By* P. B. Du Chaillu.

The author commenced by giving a general description of the region of Western Equatorial Africa, which he traversed during his last journey in 1864–65. There was a remarkable absence in the forests he explored of the species of animals which are so characteristic of Africa. He found neither lion, rhinoceros, zebra, giraffe, ostrich, eland, or gazelle. On the other hand, several peculiar species of apes were found, and it was the central home of the gorilla. The scarcity of birds and of animal life generally was also remarkable. The highest temperature observed in the interior was 98° Fahr., the lowest 63°. In July the heat was never greater than 72°. The hottest months were February to April, in which the rains were heaviest: as much as 7½ inches were once measured by him as having fallen within twenty-four hours. In the interior there was no distinct dry season, as on the coast. The author never, except on two occasions, saw the sky entirely free from cloud; and the cloudiness of the heavens increased the further he marched towards the east. Whilst making astronomical observations at night the sky would very often become suddenly covered by a coat of grey vapour, always coming from the south-east, and lasting an hour or two, but renewed more than once during the night. The distribution of the native tribes offered some interesting peculiarities. For instance, two tribes speaking the same language are sometimes separated by a third tribe speaking a totally different language. The state of political disintegration is complete. No tribe is united under one chief, but is divided into many clans, each having its own chief; and in many cases each little village has its independent chief. The chiefs have not the power of life and death over their subjects, as in the tribes of Eastern Africa described by Speke, Grant, and Baker. Their rule is mild and patriarchal. The population everywhere was scanty, and the distinctness of the tribes he believed to have been kept up by their not having come in contact in their migrations, but, owing to the wide extent of unoccupied territory, settled down without knowing of the existence of neighbours. It is only on the river-banks that they have come into contact, as all the tribes press towards the rivers. There are no cannibals south of the equator. The curious hairy dwarfs live scattered in small hordes amongst other tribes. He found a few words in the native languages almost identical with words in the East African languages. It was an interesting inquiry, what existed in the thousand miles of unexplored country lying between the author's furthest point and the shores of the Albert Nyanza? We might conclude, however, that it was a country of considerable elevation, and probably wooded, varied, and picturesque; for Baker saw towards the west a range of mountains, and the country from the west coast becomes gradually higher towards the east. Considering also the humidity of the climate, and the small size of the rivers which find their way into the sea, it might be concluded that there was a great drainage of waters towards some inland sea, or that there were other great lakes on the equator west of Albert Nyanza.

### *On Andorra.* *By* Dr. Charnock.

### *On Cæsar's Account of Britain and its Inhabitants.* *By* J. Crawfurd, *F.R.S.*

### *On the Migration of Cultivated Plants with reference to Ethnology.* *By* John Crawfurd, *F.R.S.*

The earliest vegetable food of man, according to the author, must have been wild fruits, seeds, and roots, the species necessarily varying with climate. Some

races of man are still confined to these primitive articles. The most important of these food-plants are those which can be made into bread, such as the cereals. With the exception of rice, not one of the cereals can be traced with undoubted certainty, nor can we state their parent countries: this must be received as evidence of the vast antiquity of their cultivation. Wheat and barley must have been well known to the Egyptians before the earliest of the pyramids was built, for a people feeding on roots and fruits could not have possessed the power or the skill indispensable to the construction of those stupendous monuments. With regard to legumes, several of the cultivated kinds can be traced to their wild originals. Language often throws light on the birthplace and migration of cultivated plants, and the result of this line of investigation in regard to the cereals has been to show that they originated at many separate points. The influence of the various food-plants on the character and civilization of the races of man was dilated upon by the author, who concluded that no people ever attained a tolerable degree of cultivation without the possession of the higher cerealia. Had the food of the Britons some 2000 years ago been confined to the potato, Julius Cæsar would unquestionably have found our ancestors far greater barbarians than he describes them to have been.

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*On the Invention and History of Written Languages.*
*By* JOHN CRAWFURD, *F.R.S.*

The first attempts of man towards making a visible record of ideas must have consisted of pictorial representations of natural objects. The imperfect and untractable nature of symbolic writing must, however, have early presented itself to most nations, and accordingly two people only, the Egyptians and Chinese, appeared to have persevered in using it. Among the more precocious races of man gifted with a fair share of intellectual capacity, vocal or phonetic writing seems to have been invented as soon as such a state of society had been reached as allowed of the existence of a class of men that had leisure for meditation. There consequently exists hardly a nation of Asia, from the Mediterranean to the western confines of China, that has not invented phonetic writing and been immemorially in possession of alphabets of more or less perfection in proportion to their degrees of civilization.

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*On some of the Bearings of Archæology upon certain Ethnological Problems and Researches. By* R. DUNN, *F.R.C.S., Vice-President of the Ethnological Society of London.*

Mr. Dunn began by remarking that there was a fascination about the subject of prehistoric times and prehistoric man—about the revolutions of our globe as revealed to us by geological investigation, and of the generations of mankind by archæological researches, and that the very obscurity of the subject whets our zeal in its investigation. He asked what could be more fascinating than the wonders of geology as we ponder over the revolutions which the earth has undergone—search after the evidences of the first appearance of life upon its surface, and recognize in its successive and changing phases the varying animal forms, rising higher and still higher in the complexity of their structure up to the advent of man himself—to us the crowning theme of all these wonders. But when did he first appear? Was he pliocene, miocene, or still more ancient? All that we can assume is that in the fullness of time, when the earth was fitted for his reception by the fiat of the Almighty, man made his appearance. Then was brought into existence a being in whom that *subtle force* which we call *mind* was the grand and distinguished attribute, raising him so immeasurably in the scale of being above the whole brute creation. He dwelt on the antiquity of man, remarking that the men of the Drift shared the possession of the forest-clad valleys and plains of Europe with the mammoth, the cave bear, and the woolly-haired rhinoceros, when the British isles were alike united to one another and to the continent of Europe; observing Lartet's exploration of the Cave of Aurignac in the Pyrenees, not only as proving the high antiquity of man, but as tracing back the sacred rights of burial, and also the still more important belief in a future state of existence, to

times long anterior to history and tradition. To the cave men of those days and to the rude tribes on the valley of the Somme, with their rude flint implements, he found a parallel among existing savages and the Esquimaux tribes of the present day. Archæology, he said, was the link which connects prehistoric man with history; and, as Sir J. Lubbock had so well remarked, "they were too studied in their works—houses for the living, tombs for the dead, fortifications for defence, temples for worship, implements for use, and ornaments for decoration." In their modes of sepulchre, their tumuli, cromlechs, dolmens, and cistvaens, we had unmistakeable evidence of differences of race and of phases of civilization, for these ancient tumuli did not belong to one period nor to one race of man. In the tumuli of Denmark, during the stone and bronze ages, the distinctive characteristics were so marked and striking as to point to men of the bronze period as being a new race in a much higher state of civilization, and who had exterminated the previous inhabitants. Their very general practice of cremation had deprived us of one important source of evidence, in the shape of the skull, as to their facial type. Human palæontology, however, had made plain to us that in the pre-Celtic times there existed both a brachycephalic and a dolichocephalic race, as primitive peoples, in Europe. He next passed to the consideration of primeval man. After comparing civilized with savage man, our own condition with that of those to whom the illuminating rays of civilization had never reached, or among whom they had become extinguished, and after having pointed out, in their respective bony crania, distinctive differences impressed and stamped upon them, as unmistakeable and indisputable evidence of elevation and degradation of type, he discussed the important questions as to whether in time these types were convertible, and, if so, which was primordial.

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### *On a Proposed Ethnological Congress at Calcutta.*

*By* Sir Walter Elliott, *K.C.B.*

A congress of a novel kind has recently been proposed at Calcutta by Dr. Fayrer; namely, an assemblage of living examples of all the races of men of the old world for ethnological study; to take place on the occasion of the Industrial Exhibition to be held in 1869–70. The proposition has been warmly taken up by the Asiatic Society of Bengal. At the same time the Council of the Society suggested a modified scheme confined to the subordinate governments of Bengal, for an ethnological congress of all the tribes found in Bengal, Nipal, Burma, the Andaman and Nicobar Islands; to form part of the Local Agricultural Exhibition of 1867–68. The author proposed in his paper a third scheme, intermediate between these two, namely, an assemblage of individuals of all the races found in British India. This would be more practicable than the larger scheme, and more useful than the smaller. To show the large field for ethnological comparison in this assemblage, the existing population was described as consisting of three principal divisions. 1. As descended from aboriginal races and the servile classes; 2. from the Tamil or Dravidian races; 3. from Hindi immigrants, whose language has been modified and perfected by Sanscrit. The first are represented by the small communities inhabiting mountain-ranges and dense forests, and speaking the most ancient dialects deemed of Turanian origin. The second contains the more civilized Tamil peoples. The servile classes have naturally adopted the modern or polished Tamil, but that it is foreign to them is shown by their inability to pronounce words containing a remarkable Tamil letter, equally a Sibboleth to Europeans, and which is generally rendered by an *l*, or sometimes by an *r*. A striking characteristic of all the aboriginal races is their demonolatry, in the sense of the Greek word. They honour the spirits of their ancestors as beneficent beings. A festival observed annually or at longer intervals, in honour of the village goddess, to propitiate her protection from loss of crops or epidemic disease, affords a curious illustration of the religious belief of this class. The officiating priests all belong to the servile class; and the ceremonies consist of offerings of cattle and saturnalia. The author referred to the Dhangars as remarkable for their love of truth, and their similarity in this respect to the Gonds of Central India and the Sonthals of the North.

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*Notes on Eastern Persia and Western Beloochistan.* *By* Col. F. J. Goldsmid.

This memoir gave the principal results of journeys into little-known countries undertaken by the author (in 1864–66) in surveying the line for the Indian telegraph. The most important portion of his travels was that between Sabristan, S.E. of Kirman, and Chou, on the coast of Beloochistan *viâ* Bampur and the Pass of Fanoch. The author found that the city of Kirman lies very much more to the eastward and less to the southward of Yezd than it is supposed. In the march from Regan to Bampur Colonel Goldsmid passed along a track different from that marked on Pottinger's map: and between Bampur and the sea the road lay entirely through new country. He believed that the laying of telegraph wires through Mekran and the upper regions of Beloochistan would be productive of good results in our relations with those little-known countries—results quite as important as rapid communication between England and the East.

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Palestine Exploration Fund.—*A Report on the Topographical Results of the first Expedition sent out by that Association, towards which, at the last Meeting, a grant of* £100 *had been made by the General Committee.* *By* G. Grove, *Hon. Secretary to the Fund.*

The expedition was placed under the charge of Capt. C. W. Wilson, R.E., with whom was associated Lieut. Anderson, R.E., and Corporal Phillips as photographer. The party were well supplied with chronometers and other instruments, and their instructions were to make accurate and systematic observations between Damascus and Jerusalem. They were constantly occupied from December 1865 to May 1866. The present Report embraced the topographical investigations only, which, however, were very important. Forty-nine separate places, the positions of which were before unknown, have been accurately fixed, both in longitude and latitude, detailed reconnaissance sketches for maps have been made, on a large scale, of the whole backbone of the country from north to south, and of several outlying districts, such as the basin of the Lake of Galilee, the district of Samaria, and the valleys between Jerusalem and the sea. Passages were read from reports by Capt. Wilson and Mr. Anderson, detailing the method pursued in obtaining the observations, and testifying how carefully and systematically their work was done. An arrangement had been made with Mr. Murray by which these maps would very shortly be made public, under the superintendence of Mr. Grove himself. A very substantial step has been taken by this Association towards putting the map of the Holy Land right, and one which should encourage its supporters to still further efforts. The Report comprised a recommendation by Capt. Wilson that stations should be established and supplied with instruments for regular meteorological observations. Competent persons resident in the country had promised their services, and thus a great want would be supplied, as no observations on climate have been taken, except at Jerusalem and Damascus. Mr. Grove announced the intention of the Association to persevere until every square mile in Palestine has been properly and accurately surveyed and mapped; till every mound of ruins has been examined and sifted; the name of every village ascertained, recorded, and compared with the lists in the Bible; till all the ancient roads have been traced; the geology made out; the natural history and botany fully known. In furtherance of these intentions, a second expedition will shortly be sent out to excavate in detail at Capernaum, Cana, Samaria, Nazareth, and Jerusalem. Another party (of whom it was hoped Mr. Prestwich, F.G.S., would be chief) will attack the geology and the natural history, so ably begun by the Rev. H. B. Tristram. A work on the modern Syrians is in preparation by Mr. Rogers, of Damascus, under the encouragement of the Palestine Fund, as a companion to Lane's 'Modern Egyptians.' The names of villages, &c., are being collected by a competent resident Arabic scholar, and five meteorological stations are to be appointed, to which instruments will be furnished under the sanction of the Kew Committee. In conclusion, Mr. Grove drew the attention of the Meeting to the importance of these researches as corroborating the statements of the Bible, which purported to be mainly a record of facts, and of facts about certain definite localities. Hitherto the book has been tested by internal evidence chiefly; the time has arrived when other tests must be

applied to it—those afforded by a comparison of its descriptions with the country it describes. These tests he was confident it would stand, and he called on the members of the British Association to support the investigation.

*On some New Facts in Celtic Ethnology.* *By* HENRY H. HOWORTH.

The author endeavoured to show that the so-called Turanian race extended to Britain. Starting with the facts collected by Lhuyd, he showed, by means of the comparison of vocabularies and grammatical forms, that a large element in Celtic, whose relations have been previously unassigned, is to be referred to an Iberic source. This element was found to be much more marked in Irish than in Welsh, and explained the differentia of the former tongue. The Gascon dialects were held to be links connecting Breton with the corrupted Basque of the French provinces; and this connexion was shown to extend to Cornish. Where Welsh differs from the other Celtic tongues, it was shown to be chiefly in an approximation to Low German forms. To the Pictish Lowlanders were assigned the Welsh peculiarities of Scotch Gaelic; to the Irish invaders of Anglesea and the Cornish borderers of the Severn, the dialectic idiosyncracies of North and South Wales. Cornish was held to show a mixture of types, in which the Breton predominated; while aberrant forms connect it with Irish. These facts were considered to support the traditional connexion of Ireland with Spain, or perhaps with Aquitania, by proving Irish to be a Celt-Iberic tongue. Breton, corrupted by Belgic contact, was held to represent the language of the purely Celtic area of Cæsar—a contact exemplified in Britain, where the Cornish or Lloegrian Celtic is found bordering on Welsh. The dual elements of Welsh point to its being the language of the German and Celtic Marches or frontiers—a condition fulfilled by identifying the Welsh with the Belgæ of Cæsar. Lastly, the presence of this Iberic element in early British ethnology was considered by the author to explain much that is obscure in its oldest archæology, and to throw considerable light on the traditions of Western Europe.

*Explorations from Leh, in Cashmere, to Khotan, in Chinese Tartary.* *By* W. H. JOHNSON.

The author is a civil assistant in the Great Trigonometrical Survey of India, and the exploration which he described originated in an invitation which he received when at Leh from the Khan Bádshá of Khotan to visit him at Ilchi, his capital. The author accepted the invitation, and carrying his instruments with him, was enabled to make a good general survey of a tract of country which was previously almost entirely unknown. His memoir was of considerable length and full of interesting details. Between the Karakorum and the Kíum Lun ranges the author crossed a series of extensive tablelands from 16,700 to 17,300 feet above the sea-level, which are so free from ruggedness that a horse may be galloped over them anywhere. One of the plains bears traces of having been the bed of a large lake, and at present contains two lakes covering areas of sixteen and sixty square miles respectively. He struck the Karakash river (of Tartary) in lat. 35° 53′ and long. 79° 23′, at a point where it was 15,500 feet above the sea-level. It took him sixteen days to march from the Karakash to Ilchi. The whole country of Khotan is an immense plain, sloping downward to Aksu (fifteen long marches north of Ilchi), and watered by numerous streams, which all fall into the Argol river, and thence into the Lob Nur Lake. Six miles north-east of Ilchi begins the great desert of Gobi, with its shifting sands that move along in vast billows, overpowering everything. It is said to have once buried 360 towns in 24 hours. Fine dust from the desert was seen by the author to fill the air so densely that he was obliged to use a candle at midday to read large print, although the air was perfectly calm at the time. The country is very fertile, and equal to Cashmere in this respect. Ilchi is a great manufacturing city. The chief articles are silks, felts, carpets, and coarse cotton cloths. Its population is about 40,000, and that of the whole country of Khotan about 250,000. Ilchi lies 4329 feet above the sea-level. The people of Khotan had recently shaken off the Chinese yoke. The Khan had an army of 6000 infantry and 5000 cavalry. The author soon learned that his object in inviting a British official to his capital was to solicit the alliance of the English; and

he ran some danger of being detained as a hostage. He experienced great difficulty, owing to the jealousy of the Khan, in taking observations of the sun and pole-star for determining the latitude of Ilchi. After a stay of sixteen days, he returned by way of Zilgiá and the Karakash river to Cashmere.

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*On Priority in Discovery of the Madeira Group.*
*By* R. H. Major, *F.S.A., F.R.G.S., Hon. Sec. R.G.S.*

The authors howed, first, that the Portuguese historian De Barros exceeded the authority of the ancient chronicler Azurara, when he stated that the respective names of the islands were given by the Portuguese in 1419–20, thereby diffusing the erroneous belief that the group was first discovered by the Portuguese. The inaccuracy was shown by an extract from a map dated 1351 in the Laurentian Library at Florence, in which the group is laid down with its present names, excepting Madeira, there called Legname, of which Madeira is simply a translation. Secondly, the truth of the romantic, accidental discovery by the Englishman, Machin, in the fourteenth century, was established by a combination of arguments, in which the author availed himself of an extract from a Portuguese MS. at Munich, never yet printed, and earlier by half a century than the earliest printed account. Thirdly, he presented arguments based on the evidence of the map of 1351, in combination with other historical facts, to show that the group was discovered by Genoese in the service of Portugal, in the first half of the fourteenth century.

Politically the question was without importance, inasmuch as not only could Portugal claim these islands on the ground of the earlier actual discovery, but the accidental rediscovery nearly a century later had led to the first colonization and fertilization; and it would be as futile to dispute such a claim as it would be to negative that of the English to the colonization of Australia on the ground of those early authenticated discoveries in that vast island by the Portuguese, which it had previously been Mr. Major's good fortune historically to establish. But for those who care for history for its own sake, this paper brought into a focus a large amount of curious and interesting matter derived from MS. or little-known sources. By bringing into correlation a variety of points hitherto unobserved, the author was enabled to prove the reality of the former existence of a MS. which has been missing for centuries, but which contained not only the description by an eye-witness of the rediscovery of the Madeira group in 1419, but also the declaration of the circumstances under which it had been already discovered in the previous century. It is to be hoped that this precious MS., by Francisco Alcaforado, may not long remain a desideratum.

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*On the Kaffirs of Natal.* *By* Dr. R. J. Mann.

The number of black people in Natal, subjects of the Queen, is about 170,000. The most powerful tribe in South Africa at the beginning of the present century was the Zulus, who became greatly augmented, under their chief Chaka, about the year 1820. This great chief pursued a career of conquest until, from a very small clan, the Zulus acquired a territory 500 miles in length, the conquered tribes being absorbed or driven into the interior wilderness. The settlement of the colony by the English put an end to the tide of conquest, and a large number of Kaffirs placed themselves under British protection. The Natal Kaffirs are scattered throughout the colony, living in huts and kraals, having their chiefs, but subject to British authority. In the main, they are savages still. The question arises, what is to become of them? It is clear they show no signs of melting away before the pale-faces, as many other savage tribes have done; for by constant accessions from without they have increased in number twentyfold in thirty years. They are gradually resolving themselves into a labouring class in the colony. They take readily to labour in sugar-plantations; they are also capital managers of oxen, and make very useful indoor servants. It is difficult, however, to retain them long in one place. Some labourers work for six months, and then retire with their wages to their kraals; but they have acquired a taste for earning money, and almost always return to service. Wherever there is a white settlement near, to furnish

them with a market, or a sugar-mill, missionary stations soon get to be surrounded by an orderly and prosperous Kaffir community, growing up with great promise of steady advance. At one place there is a school for teaching English, to which the Kaffirs voluntarily contribute £70 a year; two of the black men here possess property amounting to £2000, and many own a few hundreds each. Many other facts were cited by the author, all tending to encourage hopes of the ultimate civilization of the Kaffirs, which he maintained ought to precede attempts to christianize them.

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*On the Physical Geography and Climate of Natal.* *By* Dr. R. J. Mann.

Natal has a sea-coast of 150 miles, and is separated from the drier region of the interior by a range of mountains, or rather the ledge of the interior tableland, which lies at a distance of from 100 to 140 miles from the coast. The average summit of the ledge is from 5000 to 6000 feet high, isolated peaks rising to between 7000 and 9500 feet. The climate is subtropical, modified and softened by the effects of its peculiar configuration. In area Natal is equal to about one-third of England. From the frontier mountain ledge a subordinate ridge stretches across the middle of the colony, and from this again numerous short spurs branch off, between which flow the streams, about fifty in number, which drain through the land to the sea. As the mountains rapidly increase in height towards the frontier ridge, the general gradient of the land, from the sea upwards, is one in seventy; as a natural consequence the colony possesses no navigable river, and the streams are liable to sudden floods, which impede travelling at certain seasons. Much of the excellence of the climate, however, depends on this gradual elevation. In the central region there is a perennial rainfall, and the valleys of the coasts are filled with plantations of sugar, coffee, arrowroot, oranges, pine-apples, and bananas, whilst the hills are covered with cattle, horses, sheep, and grain-crops. The northern part of the colony lies in the basin of one considerable river. In the southern parts the mouths of the numerous rivers are closed by sandbanks, which are broken through in the seasons of flood, and closed up again at the end of the rainfall. The general surface of the land is composed of an endless succession of hills and valleys, the uplands being bare pasture, the sides clothed with evergreen trees, and the rapid rivers often leap from ledges two or three hundred feet in height. The prevailing winds are from the Indian Ocean, and are heavily laden with moisture, which is discharged over the land daily in the hot season, the cool moist air rushing in as soon as the air over the land has been heated in the morning by the almost vertical sun. In Maritzburg, 2000 feet high and forty miles from the sea, there are thunderstorms nearly every third day during the six months' hot season. Summer heat in Natal is therefore remarkably tempered by the cloud-screen and the frequent showers. Almost every day in summer the sky gets cloudy soon after noon; and the mean of the month never rises to 72° Fahr. The mean temperature for the six summer months is 69°·5, the night temperature rarely descends to 52°. In the winter months the sun shines with much less intensity upon the land, and the monsoon air-currents are therefore less violent. Comparatively unbroken sunshine, however, reigns at this season, and the temperature rises to between 70° and 80° in the day, descending on rare occasions in the night to below the freezing-point; the mean winter temperature is 59°·9. In summer the vicissitude of temperature lies between day and day; in winter between day and night. The mean of the annual rainfall at Maritzburg, for eight years, gives 30·11 inches. The author exhibited a series of tables and diagrams in illustration of the meteorological phenomena of the country as observed by himself during an eight years' residence.

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*On the Aleppy Mud Bank.* *By* C. R. Markham, *F.R.G.S.*

On the south-western coast of the Indian peninsula there exists a system of backwaters which forms a continuous natural line of communication from Trivenderum to the Madras Railway, with the exception of one barrier of land. At no very distant date the sea appears to have washed the base of the ghauts; alluvial deposits gradually encroached upon the sea, checked by the waves of the monsoon, and eventually a belt of land was formed, leaving within a line of backwaters, and

becoming densely covered with cocoa-nut groves. This belt at one point forms the Aleppy mud bank; and the whole roadstead near it has a remarkably soft, muddy bottom. It is curious that this muddy bottom moves up and down the coast for about three miles, the cycle of movement occupying a period of several years. During the height of the monsoon the waters of the backwater are four feet higher than those of the ocean, and an enormous hydraulic pressure must thus be caused. In the same season, at low water, a series of mud-volcanoes are observed to form on the beach, which eventually burst and disgorge quantities of vegetable matter mixed with mud. Boring instruments on the belt of land are found to penetrate through alluvial deposit into a great depth of moving soft mud. It appears, therefore, that there is a subterranean communication between the backwater and the sea, and that the tremendous pressure from the backwater, when it is higher than the sea, forces an immense mass of mud by the subterranean passage into the roadstead. Various schemes had been proposed for cutting through the Wurkally barrier, and thus completing the backwater communication; the plan of Mr. Barton was thought the most feasible, and will necessitate a cutting of fifty feet, and two tunnels.

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*On the Reported Discovery of the Remains of Leichhardt in Australia.* *By* Sir R. I. Murchison, *Bart., K.C.B., F.R.S.*

Sir Roderick announced that on the previous day he had received from Dr. F. Mueller, of Melbourne, the news that the Leichhardt Search Expedition, now in the interior of Australia, had discovered traces of the lost explorer. The news had been sent by Dr. Mueller in great haste, the departure of the mail having been delayed a short time to admit of his forwarding the despatch, and no details of the nature of the discovery were given. Sir Roderick gave a sketch of the movements of the Leichhardt Search Expedition down to the time when the latest authentic information had been received. It had met with great losses in horses and *matériel* at Cooper's Creek; but the leader, Mr. Duncan M'Intyre, had succeeded in pushing his way across to the banks of the Flinders river, which flows into the Gulf of Carpentaria.

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*On North and South Arabia.* *By* W. G. Palgrave.

The author described the division of Arabia into two distinct regions, marked by peculiarities in physical conditions and modifications in the character of their inhabitants. The more northerly division included the highlands of Nejed, the seat of Wahabee domination, the more southerly the district of Oman. The population of the two regions is about equal. The two divisions are typified by their national colours, white for the northern and red for the southern; and wherever Arabs are found, two factions exist, who adopt these colours as their symbols,—violent factional feeling often existing amongst people who have lost all knowledge of the original cause of difference. The northern Arabs were a fine, intelligent, courteous race, with a cast of features like the typical Ishmaelite. In the southern Arabs the type was different, the skin was darker, the features were no longer Semitic, but more nearly resembling the Coptic. The institutions of the southern people were more progressive than those of the northern. The language in the north was the pure Arabic of books; in the south there were great differences both in words and turns of expression, these peculiarities not being accidental, but due to an original difference in language. It was the opinion of the most learned German philologists that the peculiarities in the idiom of southern Arabia indicated a connexion with Ethiopia, and must have originated on the east coast of Africa. The Wahabee country was surrounded by deserts, and could never be of practical importance to the English nation. It is different with Oman, which is a rich and beautiful region, similar to the district of Bombay, and will soon become much more important to us, politically and commercially, than it is at present.

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*On the Transvaal District of South Africa.* *By* Rowland William Payne.

That region of South Africa, lying between 22° and 27° of south latitude and 27°

and 30° of east longitude, now known as the Transvaal Republic, is the country of the emigrant Boers, who, disgusted with British rule and the emancipation of their slaves, left the Cape Colony, and after founding Pieter Maritzberg in Natal, again tracked further north and colonized this fertile region, then for the most part in the possession of Moselikatse, an emigrant Zulu chief, who now lives beyond the Limpopo. The Boers are physically a powerful race, but mentally and morally are in a state of retrogression, showing no improvement for a period of many years, and are as backward in civilization as any white existing race. Various tribes of Betchuana race live on the west and north-west of the Boer territory, on the east and north-east the Amatonga, and Zulu Kaffirs on the south, the Boers of the Free State, who are little in advance of their brethren, across the river. The towns are Potchefstroom, Pretoria, Philadelphia, Rustenberg, and Schoemandal. Oryxstadt, formerly populous, is abandoned as unhealthy.

The country next the Vaal resembles the Free State, in the absence of timber and the conformation of the hills, which resemble the Sussex Downs. The Drakensberg, forming up to this the watershed of the eastern and western river districts, here ceases in that capacity. The Limpopo and Oliphants rivers rising west of the Drakensberg from hills which run east to west, after flowing several miles to the north, through the Magaliesberg, &c. ranges, turn east, and fall into the sea near Delagoa Bay and Inhambane.

The Magaliesberg is the favourite district of the Transvaal, having a healthy climate, and being well supplied with wood and water.

The Soutpansberg district is much warmer, lying partly in the tropic; its inhabitants forsake farming for elephant hunting, which is here the staple pursuit. Schoemandel, the town of this district, is inhabited by hunters and traders only.

Nearly all the large wild animals of South Africa are found in the Transvaal, which is the best-watered and most fruitful district in South Africa, not excepting Natal.

Ivory, horns, and leather are the staples of trade; but wheat and the vine grow well in some districts, and it can become a wine-producing country. Delagoa Bay is the geographical port of the Transvaal, but the roads are unmade, and the bay is so unhealthy that the Boers dislike it; the Tsetze also interferes in some districts with transport. The Transvaal abounds in mineral wealth. Gold is found in great beds of quartz, which crop out through the whole of the middle districts; lead-ore is in abundance, and eventually this little district, with a more enterprising population, will exercise no small influence on the destiny of South Africa.

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*On the Various Theories of Man's Past and Present Condition.* *By* J. Reddie.

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*On the Voguls.* *By* Dr. H. Rónay.

The Voguls are a tribe of Northern Asia, residing on the river Vogul. They call themselves "Mancsis." The name of Vogul was given to them by the Szirján merchants, who, in their mercantile pursuits beyond the Ural Mountains, called those living on the river Vogul, "Voguls," and those on the river Ob (in the Mancsi language "Asz"), Osztják. The Voguls are of a dark complexion, small in stature, closely allied to the Finish type. Their principal occupations are fishing, hunting, and bird-catching. Agriculture is known only towards the south, in the vicinity of Pelim and Loszva. Their food is very simple, air-dried or smoked fish and meat; they scarcely ever use salt; bread is only known in the south. They are good-natured, cheerful, talkative, but extremely superstitious, idle, and indolent. Women are considered inferior beings. The girl, when of age, is given in marriage by her father to the highest bidder in reindeer. Polygamy is allowed, but at present very rarely met with. Their dwellings are built of the bark of trees or solid wood, of which a few are called a village, scarcely ever more than seven. They acknowledge a supreme heavenly being, called "Numi-Tarom" (High-time), the ruler of the earth, to whom, according to their belief, it would be useless to pray, for he never departs from his rule, and grants happiness to men as they deserve it; consequently it will be of no avail to pray to him. However, they have their family idols, to whom they pray in necessity, whose assistance they implore with

gifts and sacrifices. It is only of late years (since 1848) that Christianity has made any progress, though it is more than a century since Greek priests were sent to them. For the dead they have great reverence, and keep generally a figure of the departed in their houses for nearly a year. Their language belongs to the "Altai group," of which the principal are the Fin, Turkish, Mongol, and Mandsu, and amongst these it belongs to "Ugor subgroup," to which may be referred the Szirján, Votják, Mordvin, Hungarian, Osztják, and Vogul (Mansci). In 1844, on a territory of 8780 square miles, their number amounted to about 6342. Under the new rule they are rapidly decreasing in number; and we are greatly indebted to Anthony Reguly, a Hungarian traveller, who, since 1843, spent several years amongst the Voguls, collecting from their oral tradition their sacred legends and ancient history preserved only in songs.

### *On the North-east Province of Madagascar.*
### *By* Dr. Ryan, *Bishop of Mauritius.*

The author narrated a visit which he had recently made to the province of Vohimarina in north-east Madagascar, and gave numerous details of the harbours, towns, productions, native tribes, and government of the various districts. The province on the whole is mountainous, but possesses, along the courses of its numerous rivers, large and fertile valleys. The Betsimsaraka tribe was considered superior to the dominant Hovas in many respects. They keep their houses clean and neat. Many of them have beautifully fair countenances and a European cast of features.

### *A Visit to the ruined Temples of Cambodia. By* J. Thomson.

The author, in the month of January 1866, arrived at Bangkok, the capital of Siam, with the purpose of visiting the ruined temples of Cambodia, making plans and photographing them. He proceeded easterly from that place through Sunsep and Kanap to Kabin, the position of which town he determined by astronomical observation to be in N. lat. 13° 56′, and E. long. 101° 58′ 15″. He arrived at the vast temple of Ongou on the 16th of February. The buildings form a rectangle 1100×1080 yards, surrounded by a ditch 250 yards wide. From its great extent, the building appears to have been the work of generations; but from its perfect symmetry and unity, the product of a single genius, with the resources of a vast empire at his disposal. The road to it is by a path through a luxuriant tropical forest. A causeway conducts to a gallery or outer entrance 200 yards long. Ascending the worn steps of this, a colossal statue of a lion, half buried in the sand, guarded the entrance. The western gallery is supported by massive square pillars. The pillared galleries of the temple rise tier above tier, terminating in a great tower. The galleries have all sculptured stone roofs; the staircases, colonnades, and corridors are also all of sculptured stone, and the courts paved. The ancient city of Ongou Thom, situated a little north of the temple, is of superior antiquity to the temple, and exhibits more grotesque sculptures. But the architecture of the temple is more classical, the pillars have all finely sculptured capitals and bases. There is the same advance shown in the bas-relief of the two ruins; the chief of these are nearly 100 yards long, filled with figures of warriors, elephants, horses, and chariots. The inscriptions, copied by the author, are of three periods, the first of which are not now intelligible, but the last can be read by any Cambodian priest; these last, however, have no reference to the origin of the ruins. The present inhabitants have no tradition even of their origin, but believe they were built by supernatural hands in a single night. In the courts are the remains of reservoirs, which, as they lie at a great elevation above the surrounding country, imply that the ancient Cambodians possessed a knowledge of hydraulics. The stone of which the ruins are built must have been brought from the Lynchie mountains, forty miles distant. The great lake of Cambodia, *Tale-sap*, lying a few miles south of Ongou, offers the rare phenomenon of a large backwater to a river; it is filled only when the river Mekong is in flood. An outlet from the lake unites with the Mekong, a few miles distant from the lake itself, and the waters of the river flow backwards up this channel to fill the lake, the natural current being driven back. The depth of the Tale-sap is thus raised from four feet to forty-four

feet. The lake is then 100 miles long and sixty or seventy broad, and the water is not liberated until the end of the rainy season. The author exhibited to the Section a large series of photographic views, copies of inscriptions, and ground-plans.

### *Notes on the Physical Geography of the Lower Indus.* *By* Col. TREMENHEERE, *R.E.*

The immense plain of Sind presents a remarkable peculiarity throughout—1, in the entire absence of channels for natural drainage; 2, in its almost uniform slope, both towards the sea and *away* from the river banks; 3, in its mineral character. The slope of the valley in a direct line to the sea, 330 miles, is 9·3 inches per mile, and the lateral slopes on either side of the river are in many parts quite as much. The river, in fact, passes along a ridge. For 540 miles the surface slope of the Indus during the inundation is 5·7 inches per mile. The soil consists entirely of a very fine siliceous deposit mixed with argillaceous matter and mica; not a grain of sand is to be found as large as a pin's head. The solid matter in the water of the Indus during its inundation amounts to 43·6 parts in 10,000 by weight. The mean discharge of water being 200,000 cubic feet, and the mean solid matter 25 in 10,000, it results that 217¼ millions of cubic yards of solid matter are carried annually to the sea, which is sufficient to cover seventy square miles of area with deposit one yard in thickness. The author investigated the various old channels of the river, and came to the conclusion that the stream has gradually worked to the westward. He also concluded that the larger the body of water in rivers flowing through such plains, and the less the surface-slope of the plain, the more direct will be the course of the river; and, on the contrary, the sharpness of the bends of a large river will indicate the existence of a considerable slope. The longer, therefore, a river becomes by extending its delta into the sea, the greater tendency will there be to assume a more direct course. The author also carefully examined the delta of the Indus, and gave in detail the result of his observations.

### *On the Progress of the Russo-American Telegraph Expedition* viâ *Behring's Straits.* *By* F. WHYMPER, *F.R.G.S.*

The author, after exploring parts of Vancouver's Island, attached himself, in the capacity of artist, to the expedition which proceeded last year from San Francisco to survey the line for the proposed Siberian and American telegraph. There exists already a line to New Westminster, Fraser River, from which point the new line is to commence. Five vessels started with the exploring parties in July 1865; one of them proceeded to Plover Bay, in Siberia, whilst the others were to meet at Sitka, in Russian-America. The vessel in which Mr. Whymper sailed proceeded through the Aleutian Archipelago to Norton Sound, in Behring Sea, and thence crossed to the river Anadyr, in Siberia. A small screw steamer, brought on board one of the larger vessels, took an important section of the party, under Major Kennicott, to explore the Kirchpak River. The average depth of Behring's Straits between 64° and 66° N. lat. did not exceed 20 fathoms. The author returned to San Francisco in November, the fleet having deposited the various exploring parties in their winter quarters on the coasts of America and Siberia. The preparations for 1866 were on a more extended scale; and by the end of the year it was supposed that about 1500 miles of the line would be laid northward of Fraser River.

## ECONOMIC SCIENCE AND STATISTICS.

*Address by* Professor JAMES E. THOROLD ROGERS, *M.A., President of the Section.*

THE Presidents of the various Sections among which the scientific labours of the British Association are distributed have, beyond the general conduct of their several departments, the obvious and important duty of dwelling in their introductory address on the progress made during the past year in the special science with which they are for the time being identified. Nor is there ever wanting abundant

material on which this congratulatory comment may be made, as scientific research accumulates its observations, and arranges its inferences. The Mathematician, the Chemist, the Physiologist, the Geologist, the Mechanician, can point with satisfaction to the annual growth of their special sciences, can compare the demonstrations of the present with the hypotheses of the past, and can confidently claim the acknowledged progress which research and method have achieved.

The case, however, is somewhat different with the Section over which I have the honour to preside. We can but rarely claim that we have made any new discoveries in the subject which occupies our attention, for we deal with that which has been constantly matter of anxious thought long before the beginnings of other inductive sciences. Our science is as old as civilization, coeval with the first speculation on the canons of practical and political philosophy. We cannot claim to discover new elements, new forces, new economies, for we are interpreting that one force which effects the cooperation of man in social life; a force whose estimate has occupied the keenest minds since men began the habit of consecutive reflection. We have before us the phenomena of society, and we know that there is a standard, always ideal, but ever the legitimate, the chief object and aim of social practice; we know that there are hindrances to the attainment of such a standard, and in a general way that such a result may be best approximated by the wise balance of liberty and restriction. But the limits of the former and the endurance of the latter are matters of keen and constant debate, of doubt which may well be honest, even when it seems to be interested. We are invariably reminded that by the practice of men our demonstrations are forced to appear in the shape of problems, that our theories are often acknowledged to be indisputable, but are perpetually liable to dispute. No one I presume doubted, even when our system of trade was protective, that free exchange was the natural and normal state, however much it was conceived that artificial or political exigencies needed its modification. When our fiscal system, as we know now, was one mass of folly and injustice, the financiers of the age certainly imagined that they were patriotic, never doubted that they were intelligent, always affirmed that they wished to deal honestly with all interests.

But what our science lacks in novelty, what it needs in practical conclusiveness, it makes up in importance and interest. We do not, when we insist on the theoretical exactness of our principles, affect to deny that they are, perhaps must be, modified by certain overruling exigencies, and that the science and philosophy of social life will never exactly square with the habits of mankind. With many persons, the economist will always be a dreamer, the author of an impossible optimism, the dweller in a new Atlantis, in an impracticable Utopia, in a Cloud-cuckoo town of unnatural alliances. Assailing, as he constantly does, the policy of restriction, he is attacking a fortress of undoubted strength. Striving as he constantly does against a social habit, a political maxim, a fiscal expedient, a commercial trick, he is struggling to undermine a position which becomes untenable at a time its defenders are reduced to acknowledge that its defence is impolitic, though it has hitherto been thought to be judicious; mischievous, though it has seemed to be salutary; destructive, though it has been believed to be expedient; interested, when it was averred to be national. He is constantly labouring to refute men's hasty sympathies by appealing to their deliberate reason.

We cannot then dispute the disadvantage under which economic science labours, when compared with other efforts of research, whose course encounters no obstacle because it clashes with no interest, whose conclusions are accepted graciously because they provoke no prejudice and awaken no fear. But we can, on the other hand, claim no small victory in this domain of human thought, and congratulate ourselves on a progress, not the less real because it has been resisted, disputed, and won, after many laborious struggles.

In the first place, then, no science occupies a more eminent position, because none deal with such exalted purposes. Political economy is perpetuallly contrasting general with special interests, urging men from narrow ends to the broadest aims, teaching the interdependence of men, of races, of nations. The Wisdom which has parcelled the earth out for various products, all necessary towards the development of the best civilization, instructs men also in the fact that as men cannot

labour for themselves alone, so nations must needs depend on other nations, and be knit together by the strong bands of reciprocal benefit, if they would work out their own highest good. Political Economy, as Adam Smith fully recognized, does not discuss the prosperity of a single people, but proposes as its object the discovery of the wealth of *nations*. It has been the privilege of the economist to disprove the fallacy that one people's gain is another people's loss, a delusion which was not too gross to possess the mind of Bacon, as it was the secret of the foreign policy pursued by this country for many centuries, as it has been the chief cause by which national rivalries and antipathies have been developed and sustained.

In the next place, the spheres of the economist and the statesman are rapidly becoming one. Domestic legislation is increasingly interpreted on economical grounds, assailed because at variance with economical axioms, supported because in accordance with economical demonstrations. A statesman would in these days be at once bold and foolish who affected to disdain economical consequences or defy economical laws. Now at least we find all parties, the representatives of all interests, appealing to the congruity of their policy with the truths of Political Economy. The abolition of the excise duty on malt is argued from one set of economical principles, its retention is vindicated on another. The regulation of the currency is defended on grounds which involved, on the part of those who uphold our existing system, the recognition of certain causes whose regularity was supposed to partake of the strictness of physical science; while those who dispute the wisdom of our monetary laws disparage the universality of the cause, and point to other principles which they assert the legislature has ignorantly violated. But, in effect, every course of public policy, every law or custom which deals with or affects the material interests of the community, is in course of being reviewed by the light of economic science. The incidence of taxation, direct or indirect; the tenure of land; the right of settling land; the relations of labour to capital, with the artificial machinery employed to diminish or increase the share which each of these contributories demands from the gross product; the functions of credit, and the power which it possesses over currency, or conversely, the influence of currency on credit; the interference of government with labour, particularly the labour of the young; and a host of other public questions, are not or cannot hereafter be treated from a sentimental or a politic point of view, but must be discussed in their economical bearings, in their influence on the general well-being of society.

Again, the same influences are being brought to bear on the relations subsisting between this and foreign Governments. The ancient habits and instincts of political diplomacy are silently or noisily wearing out or passing away, and a new diplomacy of commerce, assuming for a time the guise of formal treaties, is occupying no small part of the ground once assigned to labours which were called into activity by distrust, and effected their purpose by intrigue. And if, indeed, impolicy and injustice are legitimately open to remonstrance, and there be any defence for interfering, either by advice or threats, with the affairs of foreign nations, when their action is relative solely to those topics which once formed the material for diplomatic correspondence; such a course of procedure is just as legitimate when a Government is wilfully crippling its own resources, and inflicting wrongs upon the nation whose general interests it is bound to maintain, by a restrictive and minatory commercial policy.

Among the various questions of great economical importance which have been before the public during the past year, there are two on which, with your permission, I will make a few brief comments. These are the contingency, at no remote date, of a considerable exhaustion of certain mineral resources in this country and the altered position which England might consequently assume, and the present condition of what is familiarly called the money market. The first of these questions raises a variety of issues, the magnitude of which cannot be overestimated; the second is a crisis unparalleled for its severity and its duration.

Attention has been called by an economist, who has exhibited great research and original thought on a number of subjects, to the relations subsisting between the consumption of British coal and its future supply. Geologists, it appears, are well-nigh agreed as to the extent of the deposits, and as to the depth within

which, according to our present and in all probability our future appliances, such deposits can be rendered available. It is further admitted that the source of motive-power is heat, and that coal is, for practical purposes, the sole material from which heat can be derived. Should the consumption of coal in this country, it is argued, progress at the same rate as now, the supply will be exhausted at no distant date, and with such an exhaustion there must ensue a cessation of most of those industries which have hitherto characterized us. So energetically was this alarm seconded by one of our most distinguished economists, that a financial operation was proposed, with a view to palliate some of the evils which might be likely to ensue from such an event.

It cannot of course be denied that a limited quantity of any natural product, the demand for which is incessant, must ultimately be exhausted. But the real question, it seems, is, when will the scarcity-price operate on consumption, and when it does so operate, in what will the saving be effected? That the scarcity-price is not yet operative is manifest from the increase in the aggregate consumption of coal, and from the increased production of metals; for it is in the smelting of metals that the largest consumption occurs. Nor can it be doubted that when the saving becomes necessary from enhanced price the economy will be exercised in this direction. But the total value of all metals produced in this country in the year 1864 (the largest in value, though not the largest in amount, yet recorded) was worth little more than 16 millions, a great but not a dominant quantity in the annual aggregate of British industry. It would seem, then, that the alarm, if it be not premature, is certainly excessive; that there will be abundant warnings of future scarcity, and necessary economies in dealing with the residue, long before that residue verges to exhaustion.

Thematerial wealth of this country, it may be observed, greatly as it is related to its manufactures, one of the raw materials of which is locally limited, is far more fully derived from its geographical position, and thereupon its trade, the advantages and aids of which are permanent. Occupying, as Great Britain does, the most central position between the New and the Old World, it is and will be, so long as its people are industrious and resolute, the highway and the mart of nations. Its commerce, by virtue of causes which cannot be reft from it, increases at a far more rapid rate than its manufactures; and if that commerce remain unfettered and unshackled there seems no limit to the width which its markets may attain.

It would not become me, in an introductory address, to enter on the vexed question of the currency, and in particular to criticise the Act of 1844. Opinions are, as is well known, broadly and sharply divided on that famous measure. The Act, as my readers are aware, is restrictive. It interferes peremptorily, on grounds, as was asserted by the late Sir Robert Peel, of the highest public expediency, with the freedom of issuing paper credit. It secures the convertibility of a paper currency, not by the circumstances which a bank might be supposed to interpret for itself, by guarding on its own account on the possible risk of seeing its paper dishonoured, but by the rigid yet not unbroken rule of a proportional issue. With some thinkers this system is lauded as one of consummate wisdom; with others it is censured as one of needless and mischievous interference with that part of the machinery of trade which would be self-adjusting without it and which is not really supported by it. As a rule, indeed, when one set of persons, confessedly competent to form a judgment, decide that a law dealing with commerce is wise and useful, and another set of persons equally competent declare that it is foolish and mischievous, it will generally be found, in course of time, that the latter are in the right. Such was the case with the Colonial System, with the Corn Laws, with the Navigation Laws, with the Sinking Fund, with the laws regulating or prohibiting the exportation of Coin, with Bounties, with Export Duties, with the Favoured Nation clause in Commercial Treaties.

It has been stated, but not I think proved, that the cause of the present crisis has been excessive, or over-trading. As far, however, as can yet be discovered, it seems to be due far more to imprudent action on the part of certain banks, who have made advances at long dates, or on securities not readily convertible. The distrust which has followed on the failure of some among these banks has led to

the absorption of a large amount of the note currency by the solvent banks, with a view to making their position impregnable. But this retention of notes, as it has limited the amount of accommodation, has indirectly raised the rate of discount; and thus it follows that as long as the rate is high the notes are hoarded, and as long as the notes are hoarded the rate will be high. It is worth the attention of the Section to consider whether the contingency of such a dead-lock as the present may not, concurrently with the restrictions of the Act of 1844, or independently of them, be rendered more frequently imminent by the increased inducements in the shape of high rates of interests offered to the public on deposit accounts.

At all events, the present state of affairs is without parallel. Once (in 1857) the rate of discount touched 9 per cent., just before the relaxation of the Act. It has stood on the present occasion for some weeks at 10; and unless British commerce is now conducted under far more favourable circumstances than it could have been nine years ago, the effect must ultimately be ruinous to the trader—must speedily be followed by a great rise in general prices, and in all probability by a glut of capital at no distant date.

The discussion, however, of purely economical questions forms in effect the least, but generally the most exciting, among the topics laid annually before this Section. Its largest business lies, and will it may be hoped, constantly lie, in the direction of statistical inquiry.

The statistics published by the various Government Departments are annually of increasing fulness, of larger importance, of improved method. Their utility cannot be overrated, their value to those who are led to familiarize themselves with these certain and unprejudiced witnesses is of the highest character.

During the past year two papers have been issued, both I believe from the Poor Law Board, or at least compiled by means of its machinery, which have had a considerable public interest. I allude to the returns of Live-Stock, and to the Statistics of the Borough Franchises. The first of these is, we understand, to be continued, and to be accompanied by general Agricultural Statistics.

The origin, as we all know too well, of these returns of live-stock is to be found in the instance of the Cattle Murrain. The preventive measures employed to check the disease, and the scheme of compensation accorded to those whose cattle were sacrificed in order to save those of other cattle owners, almost necessitated a rough cattle census. Such a census has been taken in other countries for some time past, and, in common with other agricultural statistics, has been regularly supplied for Ireland. It is to be hoped that the prejudice which agriculturists have entertained against the supply of these and similar returns will speedily be obliterated. It may, I presume, be taken for granted that no Administration wishes to use these facts for any other purpose than that of general information as to the domestic resources of the nation at large.

The value of agricultural statistics does not lie simply in the aid which they may afford in indicating the probable course of the market, and in saving it from needless fluctuations, but in suggesting what is the probable annual deficiency in supply Many years have passed since this country grew enough food for its inhabitants. That its prosperity may be uninterrupted, it will be necessary that it should rely increasingly on foreign produce. That its people should be well fed, it is necessary that every facility should be given for the growth and importation of live-stock and meat.

The Table of statistics giving information of the amount of cattle, sheep, and pigs, on the 5th of March, 1866, on the presumption that the returns are accurate, is singularly instructive. In drawing any inference on this subject, we should treat Great Britain separately from Ireland, as the importation of cattle from this part of the United Kingdom is more difficult than it would be from Belgium or France, and nearly as difficult as from Denmark and the Elbe. In round numbers, the population of Great Britain is about 24 millions.

In one particular only, that of sheep, is Great Britain on a general level with other countries. There is nearly a sheep to every head of population. But of horned cattle there is only one to about every five; of pigs only one to every nine. Were the amount of horned cattle in France proportionate only to Great Britain, France would have a little more than six millions; in fact it has rather more than

fourteen millions. The same may be said of Austria. In many of the German States the proportion is higher still. In Denmark the cattle are not very much less numerous than the population. In the United States there is rather more than one head to every two of population.

With pigs, as I have stated, Great Britain is very scantily provided. In France and Prussia the pigs are one to seven; in Austria one to four and a half. Taking the whole of Europe the proportion is one to six. In the United States there are more pigs than population.

Had the returns supplied us with information as to poultry, the deficiency would have been still more striking. In the year 1865 this country imported more than 400 millions of eggs, if the hundred of eggs be taken, as it has been from the earliest time, at 120.

I need hardly inform my hearers of the fundamental canon of prices—that when the supply of any necessary of life falls short of the demand, the price rises in a proportion which I may perhaps venture on calling geometrical; that is, the quantity available for sale is worth more, increasing according to the deficiency, than the normal or natural supply would be. The statistics of the cattle returns supply the key towards interpreting the high price of meat; and we may be sure that the price would be higher than it actually is, were it not for those improvements in stock-keeping by which cattle become more available for consumption at earlier dates—improvements which are yearly developed.

This deficiency is not greatly supplemented by importation. Small as the stock of cattle is, the annual importations do not amount to more than one-twentieth of the ordinary stock, while that of sheep is, as a rule, but one-fiftieth. During the present year even these quantities must have undergone a serious diminution. Nor is the import of meat large. The most important item is that of bacon. But even here the largest estimate will not give more than the equivalent of 300,000 pigs. The beef seems to be about equal to the supply of 50,000 oxen.

It is a matter of regret that no facts have been collected by which we might compare the present and the past supply of live stock in Great Britain It is of course always dangerous to trust to impressions, or to memory; but I cannot but be convinced that there has been a general and considerable diminution in the amount of live-stock in Great Britain for some years past. It is now comparatively seldom that agricultural labourers are able to keep pigs; it is still more rare that they breed poultry. The enormous importation of eggs suggests that the fowls kept in Great Britain are comparatively scanty. But it is probable that the maintenance of insect-eating birds is an important provision in agricultural economy, and that when we find fault with the destruction of small birds, we forget that our practice is dispensing with a still more important means for checking the ravages of insects, as well as for supplying that great deficiency in live-stock which seems to characterize our domestic economy. It is possible, too, that the abandonment of much pasture in the northern part of the Island to deer forests and grouse moors has considerably lessened stocks of lean cattle and mountain sheep.

It is a little dangerous to offer any comment on the second important contribution to the statistical information of the present year. Under existing circumstances we must, if we allude to the Electoral statistics, remember the caution of the Roman poet:—

"Incedis per ignes
Suppositos cineri doloso."

It will be clear, however, that valuable as the Blue Book is to which I am adverting, and singular as were some of the obvious inferences from its contents, the facts are imperfect and the tabulation still more so. One would have desired to see, along with the figures declaring the value of lands and tenements as estimated for income-tax, other similar charges, such as the proportion of assessed taxes, and the amount of the poor rate. It would have been well also had the distribution of the 25 per cent. of "working classes" among the several constituencies been distinctly indicated. Thus, for instance, the persons designated by this name amount to nearly all the constituency at Birkenhead; at not much less in Nottingham; whereas at Birmingham they are taken at less than a fifth, at Bradford considerably under a tenth. Is it possible that the expression "working classes"

has been variously interpreted by those who transmitted their reports to the Poor Law Board? But as the returns published in this parliamentary paper are of considerable interest, it may be confidently expected that the facts will be tabulated in a fuller manner hereafter, as they are keenly criticised at present.

The progress of statistical inquiry is not due to the direct action of the Government only, great and important as have been the aids which the various public departments have conferred on this branch of social learning. Among the scientific bodies who hold sittings in the metropolis and issue reports of their meetings and their labours, none is more industrious, more impartial, and more useful, than the Statistical Society of London. Its Journal, now in the thirty-second year of its existence, contains a mass of exceedingly important monographs and well-digested summaries, and is continually enriched by laborious and thoughtful communications. During the past year, this Journal has published more than its customary amount of statistical facts which illustrate the social condition of various European nations. There is a special value in information such as that given by my distinguished friend Dr. Farr on the mortality of children, for there cannot, I conceive, be a better gauge of the moral, the social, and the material progress of a people than a low death-rate among children. The labours of Mr. Walton and Mr. Hyde Clarke have thrown light, the former on the condition of France, a country which asserts a great social and intellectual place, and certainly occupies a commanding political influence; the latter on that of Turkey, the lowest and apparently the most irreclaimable of European communities.

I cannot but feel a lively interest in such inquiries as those which have been undertaken by Mr. Jevons. The interpretation of prices, when the facts are large enough to preclude the influence of exceptionally disturbing causes, is one of the most interesting as well as the most instructive among the whole range of economical investigations. Nothing, I believe, is more likely to correct those hasty generalizations which have formed peculiar temptations to some of our most distinguished economists than the careful analysis of prices. The illustrious corypheus of political economy, Adam Smith, was as laborious in collecting facts as he was subtle in gathering inferences; and I have been constantly struck, in following out certain researches into the history of prices, by the remarkable sagacity with which Smith occasionally anticipated or suggested the facts of social life many centuries ago.

It might be expected that there would be a close conformity between values at very remote periods of social history. The proportions subsisting between the prices of labour and food are, or should be, so close and unvarying, that we may always suspect, in fully settled countries at least, that any marked discrepancy between values at different periods is suggestive of removeable evils. For instance, if the price of food is considerably in excess of the average rate of wages, some cause, which may be eliminated or corrected, can almost always be assigned for the phenomenon. I may mention here in illustration of this rule, that during the thirteenth and fourteenth centuries the prices of barley and oats, wheat being taken at 100, are represented by the numbers 73·14 and 42·05, and that within the last ten years the numbers have been 70 and 45·95. Close as this relation is, the slight discrepancy may, I think, be accounted for by the incidence of the malt tax in the first case, and the great increase in the number of horses kept in the second. Other concurrent causes may, I make no doubt, be detected, but these I think are likely to be the most dominant.

Estimates as to depreciation and exaltation in the value of the precious metals are, however, to be made with extreme caution, because they are liable to many fallacies. Some of us may remember the alarms entertained by M. Chevalier as to consequences likely to be effected on prices by the gold discoveries. It is not, I think, too much to say that these fears, though natural, were grossly exaggerated; for in order that such inductions should be valid, they should be taken from a very wide area, and many disturbing causes should be accounted for or eliminated. The effects of unfavourable seasons and interrupted importations—it is only twenty years since the country accepted the principles of free trade, several years less than

twenty since it has experienced the advantage of that policy—should be recognized in interpreting the money value of the first necessaries of life; while the effects of speculative purchases and forced sales are equally dominant in the price current of its conveniences. To interpret a rise and fall in the value of money (the efflux and influx of which, as a merchantable commodity, is inevitably more free than that of any other article of value) by the money measure of that which is open to a vast variety of influences, must be an operation in which infinite caution is necessary, in order to prevent the inference from becoming wholly untrustworthy and delusive.

On such occasions as those in which the British Association has met in considerable manufacturing towns, the Section over which I have the honour to preside has generally had the benefit of local trade reports. In so considerable a town as Nottingham, one too which for a long time has been distinguished as the centre of important and special manufactures, the Section may hope to have the advantage of hearing these reports, and obtaining information as to local expenditure and improvement. To such reports it is our practice to give priority in so far as may be consistant with the general convenience of the business before the Section. For the rest, the committee will endeavour to group the papers which are to be read so as to make the discussions of each day as congruous as possible.

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*On the Transfer of Real Property.* *By* THOMAS BROWNE.

It was calculated, the author said, that one-third of the land in England was mortgaged. Every mortgage might be estimated to cost £5, exclusive of stamps, and to be of an average duration of only five or six years. We could therefore readily gather what an immense sum was annually paid for the preparation of mortgage-deeds alone. Perhaps in no case were the fictions of the law better exemplified than in a mortgage-deed, which was nothing better than a sham. Two-thirds of the matter was the repetition of an established form. The amount of the remuneration of the lawyers depended on the length of the deeds; and for short deeds, therefore, the payments would be ridiculously small. If it should be decided to abolish the present system of conveyance, on the ground of its artificial character, and there being no longer any reason for distinguishing between real and personal property, the time would be opportune (especially as the Board of Trade were obtaining statistical details to show the acreage of England, and the owners of landed property and the modes of cultivation) to attach to some standard survey map of England, and duly apportion by figures for reference all the landed property of England. It might be allotted, on the principle of a limited liability company, into so many shares, say one acre each. These might be issued in the form of scrip, from a foot-registry, to the present owners of the land, upon their affording satisfactory proof of ownership; and they would then be transferable in the same manner as other shares. This plan need in no measure interfere with the law of primogeniture. The author deprecated any rash change.

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*Some of the Results of the Free Licensing System in Liverpool during the last four years.* *By the* Rev. WILLIAM CAINE, *M.A., of Manchester.*

Five years ago the magistrates of Liverpool adopted the plan of granting public-house licenses to all supposed respectable persons who applied for them, without regard to the requirements of the neighbourhood in which the houses were situated, or the wishes of the inhabitants. In Manchester and other towns the wishes of the inhabitants of the districts are in some measure attended to. It may be interesting to the members of the British Association to know the effect of the new plan adopted by the Liverpool magistrates. I am able, from official returns, to lay before this Section the number of drunken cases in the borough of Liverpool determined summarily by the justices during the last eleven years; that is, during seven years while the magistrates restricted the grant of licenses in the way in which they are limited in other towns, and during four years under the new method:—

TABULAR STATEMENT OF PUBLIC- AND BEER-HOUSES, &C., IN THE BOROUGH OF LIVERPOOL, FROM ORIGINAL SOURCES, FROM 1855 TILL 1865.

| Year. | Public-houses. | Beer-houses. | Drunken cases determined summarily by the Justices. | |
|---|---|---|---|---|
| 1855 .... | 1447 | 966 | 12,819 | |
| 1856 .... | 1446 | 967 | 12,480 | Total of 4 years, 46,567; average per year, 11,641¾. |
| 1857 .... | 1454 | 973 | 11,439 | |
| 1858 .... | 1482 | 977 | 9,829 | |
| 1859 .... | 1498 | 996 | 11,037 | |
| 1860 .... | 1498 | 988 | 10,963 | Total of 3 years, 31,832; average per year, 10,610¾. |
| 1861 .... | 1528 | 970 | 9,832 | |
| | | THE SO-CALLED FREE-TRADE SYSTEM. | | |
| 1862 .... | 1544 | 1024 | 12,076 | |
| 1863 .... | 1636 | 927 | 13,914 | Total of 4 years, 53,914; average per year, 13,478½. |
| 1864 .... | 1667 | 1007 | 14,002 | |
| 1865 .... | 1793 | 952 | *13,922 | |

Let me compare the number of drunken cases given above with the number of similar cases in other towns, and, first, in the leading commercial and manufacturing towns.

LIVERPOOL COMPARED WITH THE LEADING COMMERCIAL AND MANUFACTURING TOWNS.

Birmingham had in 1864 one drunken case determined summarily by the justices in every 232 of the population; Sheffield, 1 in 195; Halifax, 1 in 175; Rochdale, 1 in 124; Leeds, 1 in 121; Manchester and Salford, 1 in 116; York, 1 in 16; Huddersfield, 1 in 75; Liverpool, 1 in 33.

But it may be said, and said truly, that Liverpool ought to be compared with seaport towns. Let us so compare them.

LIVERPOOL COMPARED WITH THE TOWNS CLASSIFIED IN THE "BLUE BOOKS" AS COMMERCIAL PORTS.

Swansea, 1 in 251; Bristol, 1 in 245; Southampton, 1 in 194; Yarmouth, 1 in 168; Hull, 1 in 105; Newcastle-on-Tyne, 1 in 95; Sunderland, 1 in 95; Tynemouth, 1 in 60; South Shields, 1 in 45; Liverpool, 1 in 33.

It is often said that the beer-houses are more productive of crime and vice than public-houses. In Manchester we have nearly twice as many beer-houses as there are in Liverpool, and Liverpool has more than three times as many public-houses as there are in Manchester. Let us compare the two towns with respect to the drunkenness and vice in them.

LIVERPOOL AND MANCHESTER COMPARED IN 1864.

(*The judicial statistics for* 1865 *not yet received.*)

| | Population in 1861. | Public-houses. | Beer-houses. | Inquests. | Drunken cases. |
|---|---|---|---|---|---|
| Liverpool.... | 443,938 | 1667 | 1007 | 960 | 14,002 |
| Manchester .. | 357,979 | 482 | 1884 | 616 | 3,587 |

| | Police. | | | Daily average No. in gaol in the year. |
|---|---|---|---|---|
| | No. of Men. | Cost. £ | Brothels. | |
| Liverpool .... | 1030 | 73,606 | 906 | 975 |
| Manchester .. | 669 | 43,713 | 410 | 639 |

In Manchester we have an enormous amount of pauperism and preventible poverty. Let us see how Liverpool stands in this in comparison with Manchester.

* Sir George Grey's Public-house Closing Act came into operation on December 1, 1864, and was consequently in force ten months of the year ending September 29, 1865, and has continued in force since.

LIVERPOOL IN RESPECT TO PAUPERISM.

*By a Parliamentary paper just issued, it appears there were indoor and outdoor paupers relieved 1st June 1866.*

| | Population in 1861. | Paupers relieved, in and outdoor. | Cost of Lunatics for 12 months, 1865. £ | s. |
|---|---|---|---|---|
| Manchester parish .. | 185,410 | 8,394 | 4312 | 7 |
| Liverpool parish .... | 269,742 | 18,435 | 9940 | 8 |

The crime of Liverpool appears to be increasing every year at a rate out of all proportion with the rate of increase of the population. A few days ago, Baron Martin, in charging the grand jury at Liverpool, said, that "never since he had been on the bench had he seen a more deplorable calendar than that of the present assizes, particularly with reference to the serious nature of the crimes. Sixteen of the cases were of homicide, and in his opinion several of the cases put down as manslaughter ought really to have been styled murder.....They were the worst list of cases of homicide that he had ever seen—he did not think he had ever seen anything so bad during the course of a long experience on the bench." On the same day, before sentencing a person charged with manslaughter, his lordship stated that "this case arose out of drunkenness, which seemed to be the cause of nine-tenths of all the crime that was committed."

At the Salford Hundred Quarter Session, held a few weeks since, Mr. Edmund Ashworth, one of the visiting justices, made a remark which ought not to be omitted in this paper. He said, "In the borough of Liverpool they had nearly 10,000 prisoners a year, and the recommitals were 58 per cent., while the number of prisoners to the population of the borough of Liverpool was 1 to 45½—the extreme of criminality of any population in the north of England, but the sentences there only average 35½ days. Some of the Liverpool magistrates had an opinion in favour of giving a license to sell liquor to almost every house for which an application was made; and looking at that state of things, and the figures already given, it appeared that Liverpool was the most drunken, and had the highest range of criminality of any town, perhaps, in England. Hence it became the duty of the authorities to consider a little the position they occupied." At this time, when cholera has invaded our shores, I cannot conclude without some reference to the alarming mortality in Liverpool—so alarming that the medical papers speak of Liverpool as "a national danger." A Liverpool paper, of the 9th instant, thus speaks of the mortality there: "Thousands of pounds have been expended in attempting to remove the causes of disease and death, and to introduce better sanitary regulations; yet fever and other contagious diseases not only exist but prevail to an alarming extent, increasing the bills of mortality so fearfully above the average of the United Kingdom that six thousand lives were sacrificed during the past year, which, in the opinion of Dr. Trench, would have been saved if Liverpool had been as healthy as other towns."

This statement is so appalling that it may well occasion apprehension, and attract the attention of comparative strangers to this town as a "national danger."

The subjoined Table shows the number of inquests held in Liverpool and Manchester respectively, from 1856 till 1865:—

THE OLD LICENSING SYSTEM.

| | 1856. | 1857. | 1858. | 1859. | 1860. | 1861. |
|---|---|---|---|---|---|---|
| Liverpool .... | 656 | 605 | 609 | 690 | 664 | 639 |
| Manchester .. | 496 | 502 | 467 | 507 | 603 | 578 |

THE SO-CALLED FREE-TRADE SYSTEM.

| | 1862. | 1863. | 1864. | 1865. |
|---|---|---|---|---|
| Liverpool .... | 70 | 870 | 960 | 2938 |
| Manchester .. | 535 | 603 | 616 | — |

The population of the districts included in 1861 was—Liverpool, 443,938; Manchester, 357,979.

DEATH-RATE IN THE REGISTRAR-GENERAL'S DISTRICTS FOR THE YEARS 1861 AND 1863.

| | Population in 1861. | Deaths. 1861. | 1863. | Increase. |
|---|---|---|---|---|
| Liverpool .... | 269,742 | 8716 | 9557 | 1141 |
| Manchester .. | 269,741 | 7425 | 8071 | 646 |

The Registrar-General's Report for England, ending March 31st, makes the following remarks respecting Liverpool:—"If the map of England were shaded to represent the rates of mortality of last quarter in the registration districts, the eye travelling from the lighter south to the darker north would be instantly drawn to a spot of portentous darkness on the Mersey; and the question would be asked whether cholera, the black death, or other plague, imported with bales of merchandise, had been lately introduced into its busy and populous seaport. Happily this has not been the case; but fever probably developed or aided by the mild and damp atmosphere of the season, and by overcrowding in an increasing population, has been busy and fatal in Liverpool and in other towns of the same county, and of Yorkshire. The annual mortality of the borough of Liverpool in the three months was excessive, and demands immediate and earnest consideration; it rose to 4·593 per cent. This implies that if this death-rate were maintained for a year, forty-six persons out of a thousand in the population would die in that time, or fifteen more than died in Glasgow, its northern rival, and nineteen more than in London."

*On the Number of Graduates in Arts and Medicine at Oxford for the last two centuries.* *By* Dr. DAUBENY, *F.R.S.*

Dr. Daubeny communicated a statement of the number of degrees of Bachelor in Arts conferred by the University of Oxford each year from the middle of the seventeenth century down to the present time, from which it would appear that the increase in that respect which has taken place is by no means proportionate to the progress of the country, in population, wealth, and intelligence.

Amongst the causes which have led to this result, he would suggest as one, the circumstance that an University education, instead of being regarded, as is the case in other countries, the fitting preparation for all the liberal professions, has by us been chiefly confined either to youths educated for the Church, or to those not intended for any profession at all.

Confining himself to the Medical Profession, he had ascertained that the number of Gradutes had sunk in Oxford from about four annually to every five millions of the population, which was the case two centuries ago, to less than one at the present time.

The reasons assigned for medical students so rarely resorting for their education to the University, may be briefly stated as follows:—

1. The prevailing notion, that neither professional knowledge, nor even the sciences regarded as preparatory to it, can be acquired so well there as elsewhere.
2. The large outlay which a University education is supposed to entail.
3. The necessity imposed upon the student of devoting the greater part of his time during his residence to the dead languages, thus throwing back pursuits of a more professional character to a later period of life than that at which they are commenced elsewhere.
4. The danger of acquiring habits and tastes incompatible with the successful career of a medical man, from daily intercourse with a class of youths intended for different walks in life.

Now the first of these obstacles has been removed, so far as relates to the preliminary studies, by the recent establishment in Oxford of a staff of Professors as efficient, and of means and appliances for the prosecution of Chemistry, Anatomy, and the like, as ample, as are to be found in any other rival institution, whilst with regard to studies purely professional, it is conceived that they can be best acquired after the preliminary ones are fully mastered, and may therefore be reserved with advantage till the time when the necessary residence in the University has been completed.

Secondly, that the large sum supposed to be required for an Oxford education,

arise not from the charges of board, lodging, and tuition, which every student must incur, but from the expensive habits and costly amusements in which so many indulge. The same evil might be avoided by any body of youths who were sufficiently numerous in point of numbers to associate chiefly amongst themselves, and who were placed where they would not be in constant communication with students of another means and different pursuits.

Thirdly, the objection raised from the undue postponement of their studies has been already in part removed by the new regulation, which enables the Undergraduate to terminate his classical reading after two years of residence at the University.

Fourthly, in reply to those who apprehend that habits unfitting for a medical man are likely to be acquired by a residence at the University, it was suggested, that the risk of this would be much lessened by establishing a Hall or College which should be reserved to principally by medical students, who would thus form a community of their own, and feel less temptation to join in the pursuits of the wealthier and idler portion of Oxford society.

It is not, however, suggested that Oxford should be substituted for London as a place for acquiring clinical instruction. All that is maintained is, that the preparatory studies, such as Chemistry and Anatomy, may be mastered as well out of London as in it, and that it can never be advisable that the acquisition of so large a part of that knowledge which is looked for from an aspirant to a Medical Degree should be compressed within the short compass of the time he is expected to reside in the metropolis, whilst all the previous years of his life, since the period of his leaving school, have been engrossed by an apprenticeship to an apothecary, with few opportunities of learning anything beyond the art of compounding medicines.

Would it not, it was asked, be more advantageous to a large proportion at least of these students, if, before they were considered old enough to reside in London, exempt from all moral supervision, they were to spend half the year in keeping terms at the University, and in there obtaining a sound knowledge of those sciences which constitute the basis of a medical education? And would it not be found sufficient for them to devote merely the remaining half to the routine of an apothecary's shop, for the purpose of acquiring whatever knowledge can be derived from such a quarter?

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*On the Lace and Hosiery Trades of Nottingham.* *By* W. FELKIN.

The author observed that the progress of the town and suburbs of Nottingham in population and material wealth during this century has been much advanced by the increase of the lace manufacturers of the place. In regard to the population of Nottingham, from the figures which appear in the population returns, much misconception prevails. Nottingham there appears to have a population of about 75,000, that is within the limits of the municipal borough only; while, including the suburban parishes, which are practically parts of Nottingham, there are about 150,000 in all. It has risen from 35,000, the number in 1811.—The following account of the machine-wrought lace trade in 1865 is based on a census made by Mr. Birkin and Mr. Heymann in 1862, of the machinery in the business, and given by the former in his report to Class 24 in the London Exhibition of that year. At that time there were 1797 circular machines making bobbin net; of these 200 were at Tiverton, 100 at Barnstaple, 360 at Chard, 500 in Derbyshire, and 700 in and near Nottingham. Also 1588 levers, 125 traverse warps, 42 pushers, all in Nottingham and its neighbourhood, making a total, with 353 standing, of 3552 bobbin net, and 400 warp lace frames. Of these, 2149 were making silk lace, and 1450 cotton lace. There were employed on plain net 1442, and on fancy 2157, the latter being closer imitations of cushion lace than ever before made. Although since 1862 there have occurred great fluctuations in demand, and the prices of both silk and cotton materials have advanced full 75 per cent., the amount of machinery and employment was in 1865 about the same as in 1862. The entire production continues to be finished and sold in Nottingham, except that at Tiverton, which is of silk, and sold in London. The approximate number of hands employed in 1865 is calculated upon the account taken by the writer recently of the hands actually engaged in making and finishing the production of lace from a large body of bobbin-

net machines. These, for the whole body of the lace machinery, may be thus stated:—900 men employed in 180 shops for making machines, bobbins, carriages, points, guides, combs, needles, &c., at average wages of 33*s.* a week; 10,300 men and youths at work in 130 larger factories and in lesser machine shops, 1800 of whom may earn 16*s.*, 5000 25*s.*, and 3500 first-class Levers' hands 35*s.* a week on an average. These all work alternate shifts of four and five hours each, in the entire day of 18 hours, during which the engine is going. 4200 boys clearing, winding, threading bobbins, 5*s.* 500 women filling bobbins and overlooking, 12*s.* 15,000 brown net menders, who usually receive nets from factories, and free them from foul or uneven threads. It is generally supplementary labour to household work, by which 4*s.* to 8*s.* may be gained, averaging 5*s.* a week. 300 men, warpers, 25*s.*; 300 men, moulders, founders, and superintendents of machinery, 35*s.*; 60 carpenters, 30*s.*; 360 porters, 17*s.*; 120 carters, 20*s.*; 90 watchmen, &c., 20*s.*; 260 steam engineers, 22*s.*; 150 bleachers, 30*s.*; 100 male dressers of lace, 8*s.* to 30*s.*; 900 female dressers, 10*s.*; 1000 female white menders, 12*s.*; 500 female lace-folders, 10*s.*; 1000 paper-box makers of both sexes, 7*s.*; 450 warehouse women, 13*s.*; 250 female overlookers, 15*s.*; 100 draftsmen and designers, 40*s.*; 1300 warehousemen and clerks taking salaries. There are employed in each finishing lace warehouse from 6 to 600 females, as the size and nature of the business may require. The number cannot be known except by actual census. They are taken from outdoor hands in brown-mending and other employments on lace. The hours are 8 A.M. to 6 or 7 P.M., and the wages are about 9*s.* on an average; overtime is paid for. The kinds of work must be seen to be understood, but are in general more wearisome than heavy. In some of the factories and work-rooms, in lace warehouses, and in dressing-rooms, the heat is sometimes oppressive. In general ventilation is provided for, but hands do not always care to make use of it. There is a far greater number of females employed, sometimes from a too early age, in the houses of "mistresses," often their own mothers, upon drawing, scolloping, carding, &c., processes light and simple enough, upon goods which have been obtained from finishing houses. These young people must exercise care and cleanliness on the goods, or they would be spoilt. When returned to the warehouse the mistress receives a price, out of which she takes a portion for her labour, risk of damage, fire, light, house-room, &c. Some of these persons employ twelve to twenty young girls. The total number cannot be known accurately except by census. It being considered domestic employment, they are not under registration or visitation, except upon complaint made on sanitary grounds. A great improvement has been going on in regard to the age at which these children begin to do this kind of work, and the hours of their daily labour. The change dates from Mr. Grainger's report on this important subject in 1844. The remaining department of female labour in connexion with the machine lace trade is that of embroiderers with hook or needle, Tambourers, or lace-runners, once amounting to 150,000, now reduced to a sixth of that number. Their average weekly earnings in 1836 was 4*s.*; now it is doubled, and more for the better kinds of work. As fast as the improved machinery produced figured work, nearly finished on the machines ready for sale, the lace-embroiderers were cast aside. About 1840 an emigration set into Nottingham from all the districts within fifty miles, to supply the increasing warehouse and outdoor female labour required in both the lace and hosiery trades. There has thus been added to the already preponderating female population of the place 13,000 within the last 26 years. In these three classes are computed from 90,000 to 100,000 females, which, added to the 38,000 above enumerated, makes a total of about 135,000 employed in the lace trade of Nottingham in 1865. The materials worked up cost about £1,715,000; the wages and profits amounted to £3,415,000 or thereabouts; and the net returns may be stated at £5,130,000.—In the hosiery business of Nottingham there were at work in 1865 11,000 narrow hand-machines, employing domestically 7500 men and 3500 women and youths, at wages from 6*s.* to 26*s.*, averaging by the statements of the hands themselves 10*s.* 6*d.* weekly; also 4250 wide hand-machines, likewise domestically employing 4250 men, from 10*s.* to 30*s.*, averaging, according to the workmen's statement, 15*s.* weekly wages. These 15,250 hand-frames were place in 4620 shops in 80 parishes spread over the county of Nottingham. The entire average wages of 42,000 frames in 1844 was about 6*s.* a week only. These two

classes of hand-machines, it is computed, give employment to about 20,000 women and girls as winders and seamers, earning 4*s.* each on an average. There are about 1000 wide-power rotary frames, employing 700 men, at from 20*s.* to 32*s.*; and about 16,000 girls and women, seamers and winders, on an average of 5*s.* weekly. There are about 1200 sets of circular round-power frames improved, employing 500 men and 500 youths, at from 12*s.* to 35*s.* weekly; and 1000 women, getting 12*s.* to 20*s.* weekly wages. The winders, cutters, menders, and others attached to these are about 11,000 women and girls, averaging 7*s.* to 12*s.* a week. And there are about 400 warp machines making hosiery by power, employing 400 men, at 14*s.* to 35*s.*; and 200 youths, at 12*s.* to 20*s.*; besides 400 warpers, &c. (men), gaining about 25*s.*; and also 2000 women and girls stitching, &c., at 8*s.* a week on an average. It is probable that there are 2000 men employed in bleaching, dyeing, &c., and as porters, &c., at 20*s.* to 35*s.* weekly; besides 5000 menders, folders, &c., working in warehouses, at from 8*s.* to 12*s.* weekly. To these must be added the warehousemen and clerks in 80 establishments for finishing and sale of goods in Nottingham. The Nottingham hosiery business is now believed to be giving employment to about 17,000 males and 44,000 females—together, 61,000 workpeople. The estimated returns amounted in 1865 to about £3,000,000. The two staple trades of Nottingham, therefore, distributed in returns an amount of somewhat more than £8,000,000 sterling last year, and furnished, in the aggregate, employment to nearly 200,000 workpeople. The hosiery hand-frames here stated were enumerated throughout the whole trade by my census in 1844; and the results are given with much minuteness in a paper read in this Section at the York Meeting of the British Association, where the terrible details of suffering then, and for forty years previously, endured, caused much interest and sympathy. Happily the state of things then described is now entirely changed, and the labour of the stocking-maker being in larger demand than the supply, both employed and employer are enjoying an amount of prosperity never before realized, but which, we hope, may be long continued. It will be an explanation of some interest to those who are strangers to the process of these trades, to state that the hand-knitter of a stocking, if assiduous and clever, will knit 100 loops a minute; and that Lee, on his first machine, made 1000 of worsted, and on his second 1500 loops of silk per minute. The visitor may now see made on the round frame, patented by Brunel in 1816, but since modified and improved, without any effort of the attendant but to supply yarn, 250,000 loops of the finest textures made, in various colours, per minute, with safety; an advance of 2500-fold upon the hand-knitter. Also, that while a pillow-lace maker can form 5 meshes per minute by her skilful and pliable fingers, Heathcote, on his first essay upon his bobbin-net machine, made 1000, and, before the expiration of his patent, 10,000 of these meshes per minute; a man sitting to overlook his machine now will watch its movements, producing 50,000 meshes per minute—an increase of 10,000-fold on the cushion labourer's arduous and painstaking task. The mathematical nicety of the construction of each of these machines necessary to their secure working, the beautiful simplicity of the looping stocking frames, contrasted with the complexity and rapidity of movement through confined spaces of the thousands of bobbins and carriages, in the mesh-making and embroidering bobbin-net machines, will be found to surpass the greater part of the machinery employed in any other manufacture whatever. Two or three particular points in connexion with the present operations of these trades will interest this Section. A hundred years ago almost all stockings were widened and narrowed on the frame, as they had been by hand-knitting, so as to fit the leg and foot exactly with neatness and comfort to the wearer. These were called full-fashioned hose. Seventy or eighty years ago the practice of making goods straight down in the leg first began; these were called *spurious* goods. From that time till 1845 Parliament was on several occasions informed that this practice caused distress, and applied to to declare this mode of making stockings illegal; but these petitions were without legislative result. Brunel's round frame makes knitted socks without fashion, and the round web is shaped by scissors and sewn up by stitching machines or hand. One head will produce weekly 30 dozen of women's hose, sold at 3*d.* to 6*d.* a pair. At first these goods were hateful to the greater portion both of masters and men. So far from the trade being ruined, it has become better than for a century past, in every

branch. No doubt several thousands have been at work to produce this result; but, meanwhile, we are clothing the feet of millions of people, who twenty years ago knew nothing of stockings; and will in all probability prove precursors of demand for the better and more costly articles; 30,000 persons are employed by these round frames. In the working of power lace machines there is the anomaly of eighteen hours' continued working of the engine in the midland factories. The women and children are now withdrawn from night labour. It is more than questionable whether the natural hours of adult male labour might not now, if universally adopted, result in, at least, equal advantage to the owners of these machines, costly as they are, yet working to little profit, and with greater comfort to the workmen and their families. In conclusion, the condition of the children, probably not much lower than 40,000 employed by mistresses, and the circumstances attending such numbers being confined so many hours in rooms not intended for workshops, would seem to call for authorized inspection, and, I think, for registration also.

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*On Inventors and Inventions.* *By* G. Bell Galloway.

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*On the Subjects required in the Classical Tripos Examination and in the Trinity College Fellowship Examination at Cambridge.* *By* James Heywood, *M.A., F.R.S.*

The author contended that a wider range of subjects in the triposes or examinations for honours at Cambridge and in the fellowship examinations would raise the standard of qualifications for schoolmasters, who are often selected from the classes of honour-men and college-fellows at the University. Royal Commissioners, who regulated public schools and academical studies in the reigns of the Tudor sovereigns, no doubt acted conscientiously according to the ideas and enlightenment of the sixteenth century; they followed in the same line with their Roman Catholic predecessors, deeming Latin and Greek learning the only sure basis of the higher education of the country. An example of their plans for the supremacy of Roman and Grecian studies may still be seen in the papers which are every year set to the candidates for fellowships at Trinity College, Cambridge. Of nine papers appointed at this fellowship examination, six are classical, two mathematical, and one comprises mental and moral philosophy. It is probable that a revision of the Cambridge Classical Tripos system will shortly take place in the University, and Mr. E. C. Clark, late Fellow of Trinity College, Cambridge, has suggested that both the verse composition papers in Greek and Latin should be omitted from the subjects of examination for the Classical Tripos; he proposes to substitute for them a general philosophical paper, and a philological paper, including questions not only relative to the languages of Greece and Rome, but also to the connexion between these and other languages. Such an alteration would enlarge the scope of the Classical Tripos, and increase the knowledge of the future schoolmasters, who distinguish themselves whilst at Cambridge in that important examination.

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*On the Practicability of employing a Common Notation for Electric Telegraphy.* *By* J. G. Joyce.

The author proposed a very elaborate scheme for the establishment of a system of international electric telegraphy. He suggested that numbers should be used instead of words, the suggestion being derived from the fact that signals between ships of different nations were made by means of numbers.

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*On the State and Prospects of the Rate of Discount with reference to the recent Monetary Crisis.* *By* Professor Leone Levi.

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*On the Influence of Science Classes in Mechanics' Institutions.*
*By* E. Renals.

The paper first sketched the history of these classes, and then traced their influ-

[illegible] in the Institution. In [illegible] the subject of science classes was brought under the notice of the committee by Mr. Buckmaster, the organizing teacher of the Science and Art Department. Subsequent inquiry and deliberation led to the commencement of a class in Leicester for the study of inorganic chemistry, Dr. Wilson undertaking the duties of teacher. An introductory lecture was delivered in the afternoon of a Saturday to workmen occupied in [illegible] and [illegible] the manufacture of which [illegible] the class numbered sixty-[illegible] lectures were delivered during the six months from October to [illegible] and in the May following prizes were awarded to those students who had passed the examination appointed to be held by the Council of the Science and Art Department. In 1863 the class was resumed by the same teacher, when, as might be expected, the novelty of the movement having passed away, the students were reduced to seventeen. In 1864 two classes were organized, one for the study of [illegible] being added to the inorganic chemistry class, and both being conducted by the same teacher. In this year there was a considerable increase in students, the inorganic chemistry class having sixty-five, and the physiological class thirty. In 1865 a further step was taken, three science classes being organized, namely, an inorganic chemistry class, with twenty-five students; a physiological class, with thirty-two students; and a geological class, with thirty-seven students. A former student in the chemistry class, Mr. Sissling, who had passed the examination for teachers required by the Science and Art Department, took charge of this class, and Dr. Wilson superintended the classes in geology and physiology. From these figures it will be seen that in the session which has recently closed there were ninety-four students in the Science Classes of the Nottingham Mechanics' Institution. The writer next proceeded to show by the yearly returns, that during the period in which these classes have been organized, a large number of persons, especially young men, who are employed in the various branches of local manufactures, have become members: in fact, that the institution has steadily increased in numbers since the time when the committee adopted science classes as a part of the plan of instruction to be followed. In 1862, the year in which the Chemistry class was first commenced, the number of ordinary members in connexion with the Mechanics' Institution, paying a subscription of 6s. per annum, was 772; in 1863 the number rose to 915; in 1864 it was 922; in 1865 it advanced to 1025; and at the beginning of the present year there were 1105 ordinary members. The conclusions arrived at from these facts were:—1st. That these classes draw the attention of the more intelligent among the working population to the institution in which they are conducted, and in this way lead to an increase of members. 2nd. The discipline of mind required to follow the teacher through a course of lectures creates a taste for reading and study, which it was the aim of those who founded Mechanics' Institutions to develope and gratify; and therefore the formation of science classes is the legitimate outworking of these institutions, in providing the education as contemplated as desirable to place within reach of the working-classes. 3rd. The establishment of science classes is calculated to exercise an important influence on the manufacturing interests of the community, by bringing to bear on production a higher degree of intelligence acquired in the class-rooms of mechanics' institutions, and so utilizing it for the general advantage of the community. 4th. That the systematic teaching of the sciences in mechanics' institutions is essential to the full development and successful pursuit of many branches of trade, and follows naturally in order the establishment of Schools of Art as a means of improving the character of manufactures in which design and decoration form important features. 5th. That the organization and maintenance of science classes are rendered necessary by the keener competition among nations which spring out of that unrestricted commercial intercourse towards which all countries are gradually approximating. 6th. That any outlay on the part of the Government in the more general and effectual diffusion of scientific knowledge among the people through the instrumentality of these classes, will be returned a thousandfold in the multiplication of resources through the extension of trade which invariably results from higher excellence in production. The paper concluded with remarks on the practical application of the knowledge acquired in the

class-rooms to the various branches of industrial pursuits in which the population of this country are engaged.

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*On the Diminution of Accidents in Coal Mines since the Appointment of Government Inspectors.* *By* GEORGE SENIOR, *F.S.S.*

After briefly explaining the Acts of Parliament relating to the inspection and management of mines, the author showed that the saving of life from gas explosions in pits amounted to nearly fifty per cent., and from accidents in the shafts to forty-six per cent. since the appointment of inspectors in 1854. The average loss of life in raising coal in 1864 was 1 to every 110,000 tons raised.

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*On Hindrances to the Success of Popular Education.* *By the* Rev. C. SEWELL.

The author said that our imperfect success in education must not be charged upon the construction of the system we had adopted, but upon its administration. It was almost impossible to plant an organization in an inorganic mass so as to be prolific; and for all purposes of popular education England was thoroughly inorganic. Her education had always been done for her. What popular education she had had in past generations had come from charity, neither general nor systematical in its operation. What little the State had done had been done by the free royal bounty of an Edward or an Elizabeth. England had never felt her want of education sufficiently keenly to submit to direction in the matter. One great secret of the success of popular education abroad is, that the preparation of a system of instruction and the preparation of the people to receive and use it had gone hand in hand. The absence of such a natural organization to work out the system of education was a great hindrance to our success. It was the statesman's duty to supply such an organization, and it was the educator's to supply a system and method of instruction. It would be no unworthy occupation for a statesman to win the legislature to sanction an ordinance which should compel every part of our country to provide the means of education for the poor, as it is already compelled to find them food and shelter in distress. It appeared to some not impracticable for the religious bodies and the State to work in real harmony together, and not, as it were, upon the terms of an armed truce. After dwelling on the fact that many children were not sent to school for various reasons, such as the ignorance and greed of the parents, he said he doubted whether it would be wrong to impose some restriction on a parent's right to his child's labour, when he had not intelligence enough to consult that child's interest. Whether the State regulated the attendance of children, or, the next best thing, regulated their absence, it would be intolerable that the State should organize so great a boon, and her subjects be left at liberty to neglect or ignore it.

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*Statistics of the Charitable, Educational, Industrial, and Public Institutions founded by the Native Gentry of India during the last five years.* *By* Colonel SYKES, *M.P., F.R.S.*

The author commenced by giving an account of the contributions during the years 1862 and 1863, which had been given by fire-worshippers, Hindoo idol-worshippers, Jews, Jains, and other natives for educational, hospital, and other purposes. He gave numerous instances of the spontaneous and princely munificence by which many of the native gentlemen had distinguished themselves. For example, David Sassoon, a Jew, gave £5000 for the erection of an hospital at Poona for all creeds and opinions, and supplemented that sum immediately by a further sum of £10,000 for its endowments; Nerwanjee Framjee gave £16,000 for establishing a fund for the relief of indigent Parsees of his own community; David Sassoon, a Jew, gave £4000 for the erection of a synagogue for his own community; Kursondass Mahadowdess, of Goojrat, contributed voluntarily the sum of 1000 dollars for the relief of families who had suffered by the war; Cowajee Jehsangeer, a Parsee, came forward with £5000, which he offered to increase to £10,000, if necessary, for the establishment of a strangers' home in Bombay. The author then proceeded to give

details as to the amount of these contributions for charitable and philanthropic purposes, given by certain influential native gentlemen in India, showing that in many cases the contributions of one individual during a single year amounted to upwards of £5000, and that all these contributions were voluntarily given without regard to any sectarian feeling or prejudice of any kind whatever. Amongst the subscriptions he mentioned was one for the presentation to the Prince and Princess of Wales of some of the choicest products in India. The object of supplying the particulars contained in this paper was, he remarked, to prove the character of the minds of the people of India, who are British subjects. He concluded with a few remarks on female education in India, remarking that from the feelings which were now developing themselves among the people of India, at least among the educated classes, there was reason to believe that a change would yet take place in that country by which the native women of India would be improved in their social position, and there would be a softening of men's manners, minds, and habits to an extent that was much required in India. This change had already to some extent taken place, for he could give instances of elevation of sentiment, of high honour, of delicacy of feeling, and of personal sacrifices on the part of the people of India, which were not only creditable to them, but would have been so to the most enlightened among ourselves.

Colonel Sykes said, that when the donations which he had mentioned were made to any educational institution in India, they were made without any condition stipulated as to the teaching or government of the schools. The public schools of India were all secular, and the missionary schools, which were established by different religious denominations, were regarded as being simply private institutions.

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### *On Modes of Banking in America, Manchooria, and China.*
### *By* Colonel Sykes, *M.P., F.R.S.*

The author gives an account of the devices of Mr. W. W. Brown, an emancipated slave in America, to set up a bank, after a visit to Europe. Cheated out of his first wages in the autumn of 1835, he visits a barber in Monroe, Michigan, and asked employment as a journeyman barber. Failing, he set up in opposition, and engaged a room opposite, and placed a sign over the door, "Fashionable Hairdresser from New York, Emperor of the West." Not succeeding, he was advised by a friend to set up a bank, after the manner of the "Wild Cat Banks," the notes of which were called "Shinplasters," his capital being to the value of 20 dollars. But he soon experienced the difficulties of "a run" upon his bank from the jealousy of the opposite barber, and a ludicrous account is given how the redemption and recashing of "Shinplasters" was effected.

With respect to banks in Manchooria in Tartary, the information is obtained from Mr. Consul Meadow's Report to the Foreign Office. He gives a description of Manchooria bank notes. There is not any regulation of paper currency. One hundred and twenty-three houses in Manchooria issue notes at pleasure, expressed in "*teaous*"—a teaou being equal to about 9¾*d.*, or about 50 equal £2. The smallest note issued in Manchooria is equal to 2 teaous, or 19*d.*; the largest, 50 teaous, or £2. The rate of exchange between notes and silver bullion alter daily in each city. The bankers meet every morning at daybreak to settle the exchange. The rate during the last five years, dated from 1861, averaged about 5 teaous for 1 tael, or 6*s.*

The banking system in China is described in Joshua Doolittle's 'Social Life of the Chinese.' The following are heads of Doolittle's information:—Banking is not controlled by Government. Bank bills are issued on behalf of the Imperial Government at Fouchau. Iron coin at par with copper. Value of dollar in 1858. Iron cash and Government bills withdrawn. Bankers numerous and wealthy. Denominations and values of bills. Little risk from counterfeit notes. Description of bills. Security against counterfeit. The demand of customary usage upon new bankers' bills, paid in gold or silver, &c., according to current rate of exchange. If bills not redeemed, the value of same can be seized. Panic in 1855. When an *honourable* banker is uncertain of his position, he posts these words on his premises, "*hereafter pay*," which applies to present bills; and he does not propose to issue

more bills of his own. "Hereafter pay" is published when a run is suspected Arrangements with mandarins at "running." Their effect. Considerations anent *gutting* of respectable bankers. Two Chinese beheaded for "gutting" a bank. Effect upon the population. Chinese speculators in silver. Their course of procedure and influence in regard to speculations. Description of coin.

Value of dollar at different dates. Fluctuations of silver in Fouchaw. Paper money first invented by Chinese. First used by the Government in 9th century, continued, with intervals, till 15th century. Promissory notes. Gives an account of money-lending clubs without interest. Mode of procedure of head or principal, *i. e.* the party who wants the money. The shaking club. Illustration of same. The Snake-casting-its-skin Club. Why so called. Mode of procedure. The Dragon-headed Club. Why so called. Illustration of procedure. Such are the titles, and the details in Doolittle's book are most complete.

Colonel Sykes concludes by recommending the facts stated to the careful consideration of the advocates of "*free banking.*"

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*On the Violation of the Principles of Economic Science caused by the Law of Distraint for Rent.* *By* CHARLES TEBBUTT.

The author contended that the law of distraint for rent was a violation of the principles of Economic Science, especially as regarded land, the owner of which often had a security not possessed in houses, in the investment of capital, which was irremoveable. The law secured rent to the landlord, even if he had so neglected his duty as to choose for his tenant a man utterly without skill, character, or capital. The violation of its equity was equalled by its impolicy, as it affected the occupation and cultivation of the soil. Ownership was a great inducement to the development of the cultivation of the soil; but in England little land was owned by its cultivator. It was needful that in an arrangement between landlord and tenant nothing should interrupt the play of motive and interest. Yet at this point in stepped the law of distraint, giving absolute security to the landlord, and removing from his mind that pressure of motive and interest which rendered it needful for him to have the best tenant he could obtain, and to make him every reasonable concession to obtain this end. The whole equity of the transaction was lost; little weight was given to the skill and capital of the tenant; and the landlord was enabled without danger of the loss of rent to bring in any man of straw to compete with the tenant of capital and skill. A lower standard of cultivation prevailed generally than would be the case if the disturbing law were entirely abolished.

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*On the Statistics of the General Hospital, near Nottingham.*
*By* JOSEPH WHITE, *F.R.C.S.E., &c.*

This paper was supplementary to one on the Medical Topography of Nottingham, read before the British Medical Association, and referred to the returns of the Institution during 10 years, tabulated as follows:—

I. Annual admissions, distinguishing *sex* of patients, and arranged according to the diseases or injuries for which they were admitted into the hospital.
II. *Ages* of patients, without distinction of sex, according to the same arrangement.
III. Duration of illness previous to admission into hospital.
IV. Time of stay in hospital.
V. Result of treatment.
VI. Occupations of patients.
VII. Period of the year in which they were admitted.
VIII. Locality from which they were received, as town, suburbs, county of Nottingham, or other counties.

There were admitted into the hospital during this period 6936 males and 4880 females, being 100 males to 71·3 females, a proportion which had been found to hold very nearly during each of the ten years, and which agreed, within a very small number, with similar returns from fifteen other provincial hospitals; whilst in ten of the London hospitals the proportion of males to females was found to be 1491 to 1143, or 100 to 76·7.

After analyzing the above Tables, which referred especially to the medical statistics of the hospital, another Table was added, which bore more particularly upon the subject of hospital economics and management. This Table extended over a period of thirty-five years, from 1831 to the present time, and showed, in the first place, the number annually admitted into the hospital, and of those attended to as out-patients. Both these bore a proportion to the rapidly increasing population of the town, and the latter was also somewhat affected by the state of trade, which in times of activity caused a number of accidents of a comparatively trifling kind to swell the number of out-patients. It was noticed as a remarkable fact that, in a population whose occupation brings them constantly into contact with weighty and complicated machinery, the vast majority of injuries received by those engaged in the lace and hosiery manufactures were of so slight a kind as to render admission *into* the hospital unnecessary. The number of more serious accidents occurring amongst the large manufacturing population of the town and suburbs was far outweighed by those from the colliery and agricultural districts of the county.

The 3rd column (the average number of patients in the house) of course varied nearly in a direct ratio with the numbers admitted, but not absolutely so, as it was influenced by the number of days during which each remained in the hospital, the average of which was shown in the 4th column. The latter return had always been considered a most important point in the economy of the hospital. Various causes tended to prolong the stay of some of the patients beyond the time which might be considered absolutely desirable; and for this reason it had been the practice in the Nottingham Hospital to have, on the first Tuesday in each alternate month, a general inspection by the whole of the medical staff of such patients as might have been in the house upwards of eight weeks. Those patients whose cases required further treatment in hospital were then recommended to be retained, whilst those who would be equally benefitted as out-patients, or those who were not likely to be further relieved by remaining in the wards, were recommended to be removed as soon as possible. By the careful carrying out of this arrangement a great saving to the hospital was effected, and room was thus made for the admission of those urgent cases which were generally waiting for beds. By these and other means the average number of days during which the patients have remained in the hospital had fallen in thirty years from 50 to 35·7.

The 5th column showed the total cost of the Matron's department (*i. e.* provisions, coals, gas, water, &c.) in each year, and as this was of course influenced by the varying price of provisions, the contract price of meat and bread, a fair index of that of other articles of consumption was given in the two following columns, 6 and 7.

The 8th column gave the annual cost of wines, spirits, and porter; and the 9th that of medicines, instruments, and appliances.

There was one item under the latter head which had in a few years undergone so remarkable a change that it was thought deserving of a separate column. This was the cost of leeches, which in 1835, with an admission list of 750 in-patients and 1650 out-patients, amounted to the sum of £90; whilst ten years later, in 1845, with 1214 in-patients and 3069 out-patients, the same item of expenditure had fallen to £53 10*s.* 6*d.* Since that time, with a rapidly-increasing number of patients, there had been a rapidly decreasing cost of leeches, so that in 1857, with 1379 admissions into the hospital, and an out-patient list of 7520, the cost was only 12*s.* 10*d.*, and in the following year, with 1361 in-patients and 7724 out-patients, the cost was still only 13*s.* 1*d.* Since that time the sum paid for leeches had been so small that its notice as a separate item of expenditure had been discontinued.

The 11th column gave the average cost of each in-patient in each of the thirty-five years, which varied from £4 12*s.* in 1836 to £2 8*s.* 2¼*d.* in 1845; but as the comparison of those years was rendered difficult by the varying time during which each patient remained in hospital, the 12th column had been added to show the cost *per day* of each patient during that period. It thus appeared that the highest cost was 2*s.* 2¼*d.* per day in 1834, the lowest 1*s.* 3¾*d.* in 1848 and 1850.

The last column gave the average cost of each out-patient, which had varied from 5*s.* 10*d.* in 1836 to 1*s.* 3*d.* in 1859, a difference which had, it was believed,

been in a great measure owing to the rapidly increased number of minor accidents occurring amongst the manufacturing population, and which, whilst they added little to the cost, tended greatly to swell the number of the out-patient list, and considerably reduced the average cost of each.

There was one result indicated in this Table, which tended to illustrate the important bearing of careful statistical returns upon the economical working of a large institution. In 1837 it had been observed that for several years the hospital expenditure had been gradually increasing in a ratio greater than the increase in the number of admissions would account for. The cost of provisions had risen in three years from £1386 12*s.* 11*d.* to £1954 5*s.* 10½*d.*, although the price of meat had fallen from 7*s.* to 6*s.* 4*d.* per stone, and the price of bread from 2*s.* 6*d.* to 1*s.* 10*d.* The cost of wine, spirits, and porter had risen in the same period from £48 19*s.* to £120 17*s.* 6*d.* The cost of medicines, from £433 2*s.* 7*d.*, to £764 2*s.* 1½*d.* The average cost of each in-patient, from £3 13*s.* 2*d.* to £4 12*s.* 0½*d.*, and the average cost of each out-patient, from 3*s.* 9*d.* to 5*s.* 10*d.*

A subcommittee was appointed to investigate the cause of this increased expenditure, and for many months this committee was employed in instituting a rigorous investigation into the whole domestic management, and into every portion of the expenditure of the hospital, and in carrying out a laborious series of experiments for the purpose of ascertaining, as nearly as possible, the precise quantity of each article of provision required for a given number of patients, officers, and servants. A plan, based upon these investigations and experiments, was adopted, for making a careful periodical examination of every article of consumption, so as to ensure that, whilst there should be a liberal allowance of every necessary wherever required, there should be no waste or extravagance; and the plan then adopted has been since that period assiduously carried out.

The beneficial result was soon apparent. In one year, with about the same number of patients, the cost of provisions had fallen from £1954 5*s.* 10½*d.* to £1669 10*s.* 0½*d.*; of wine and spirits, from £120 17*s.* 6*d.* to £84 4*s.*; of medicines, from £764 2*s.* 1½*d.* to £448 4*s.* 6½*d.*; the average cost of each in-patient, from £4 12*s.* 0½*d.* to £4 2*s.*, and of each out-patient, from 5*s.* 10*d.* to 3*s.* 6*d.* And now for nearly thirty years the effect of the labours of that, and subsequent committees, had been apparent in the continued diminution of expenditure, and the continued reduction of average cost of patients, which the several divisions of the Table tended to show.

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*On the Intoxicating Liquors consumed by the People of the United Kingdom in* 1865. *By* — WILKINSON.

Of gin and whisky, 20,811,155 gallons were consumed, and of rum and brandy 6,732,217 gallons. The wines charged with duty were 11,993,760 gallons, whilst the malt returned for brewing was 47,249,093 bushels, which gave an average of 24½ gallons per head in the year from the youngest to the oldest. The total value of this was £88,619,876. This sum exceeded by nearly 23 millions the gross expenditure of the United Kingdom in 1865.

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*On a National Bank and Payment of the National Debt. By* F. J. WILSON.

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*On the Occupation and Ownership of Waste Lands. By* F. J. WILSON.

The colonies having large tracts of land which they bring into cultivation, the question arose on what terms they should be transferred to the public. According to the laws of England and her colonies, the country belonged to a few, and the rest lived on sufferance. We had no right to bind posterity beyond the limits of necessity. All land belonged to the community, the Government of which had no power to sell, but simply to let it for the benefit of the community and the occupiers who were anxious to cultivate it. Therefore, all lands should be let at an annual rental of £10 per cent., or the produce of the farm with a permanent right of possession, so long as the land might not be required by the community for more important purposes, when the full value should be paid to the occupier for all

the improvements he might have effected in the property. No person shall have power to hold another person as tenant, provided such person is willing to pay on the land he may farm for such improvements as have already been expended, thus becoming the proprietor. The result of such a system would be, that no occupier of land would sublet it to a tenant, but farm it himself. Should he have more than he could farm, he would surrender it for sale, and therefore the farms would be large and productive, and the inhabitants of villages and towns claiming through the corporation such lands as they may require for building purposes, paying of course to the occupier the full value of his improvements, would not, as in England, be crammed into narrow streets (for example, this very town of Nottingham) and miserable cottages, but would have creditable homesteads, which they had been enabled to purchase at a reasonable price, still paying the increased ground-rent to the State on the increased value of the soil.

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*On Classification of the various Occupations of the People.* *By* F.J. Wilson.

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*On the Disproportion between the Male and Female Population of some Manufacturing and other Towns.* *By the* Rev. A. W. Worthington, *B.A., of Mansfield.*

The population of England appears by the Census of 1861 to be divided in the proportion of 105 women to 100 men, although 105 males are born to every 100 females. But this proportion is not equally distributed through the country. The nature of employment differs in different towns and districts; and as men or women find most ready employment, one or the other predominate in number. Thus in the mining-districts of Newcastle-on-Tyne, Dudley, Wolverhampton, and Wakefield; in the steel-manufacturing town of Sheffield; in Stafford, where shoes are made; in Stone and Stoke, where pottery is the staple manufacture; in Burton, where brewing is carried on; in the barrack towns of Canterbury, Winchester, and Colchester, and to a smaller extent in the agricultural districts, such as Bakewell, and the country parts of Nottinghamshire, there is a predominance of men; while in the manufacturing towns, such as Manchester, Preston and Carlisle, Bradford and Leeds, Worcester, and more notably in Norwich, there is an excess of women. In Nottingham and Radford together there were in 1861 48,424 men and 57,820 women, an extraordinary excess of nearly 10,000 women. This excess is most marked between the ages of 15 and 60. This is also the case in seaport towns, *e. g.* Plymouth, Yarmouth, King's Lynn, Hull, and Bristol, while in Liverpool there are far more women than men between the ages of 15 and 45. More women than men live in watering-places, *e. g.* Bath, Brighton, and Cheltenham.

This attraction of female labour to manufacturing towns is not likely to diminish, but will rather increase, owing to the comparative cheapness of female labour. Its advantage is in the addition to the family income, and the independence it gives to women. But it seems to be attended with considerable evils. Where married women are employed from home, or even have work at home, there is a very large increase in the rate of juvenile mortality. This may be partly accounted for, it is true, by the want of sanitary arrangements in large towns; and in the mining towns, *e. g.* Dudley, where the rate is very high, it may be owing to ignorance and neglect; but there can be no doubt that it is very frequently owing to the inability of labouring women to give due attention to their children. Where unmarried women work away from home, and sometimes leaving home to labour in distant towns are compelled to live in lodgings, illegitimacy increases, probably attended with infanticide, even also with the occasional procuring of abortion. Thus the rate of illegitimacy is generally high where there is an excess of women. It is marked in manufacturing towns, and in Nottingham reached the high rate, in 1864 (according to the last return of the Registrar-General), of 10 per cent. on the whole number of births; while in Birmingham, where there is an average proportion of men and women, it is as low as 5 per cent., which is below the general average of the county. Again, early marriages are thus generally promoted in manufacturing towns, though this does not seem to be the case in Nottingham, where the number of women who marry under age is below the general average of the country.

Such results are not necessary; witness the case of the Lowell Mills in America, and of Bradford in Yorkshire, where the number of illegitimate births scarcely exceed the average. The means of amendment are to be found in the promotion of family life, especially by leaving the wife and mother to attend to her domestic duties, which will promote family happiness, increase juvenile health, and decrease juvenile mortality. For this purpose also the improvement of education is much needed. Both these means would also tend to decrease illegitimacy.

The legislature might continue to direct the labour and education of minors in additional fields of employment. Employers of labour might add to these beneficial results by not engaging married women, and by judicious arrangements for the benefit of their unmarried female hands.

The paper was illustrated by detailed statistical Tables.

## MECHANICAL SCIENCE.

### *Address by the President,* THOMAS HAWKSLEY, *V.P. Inst. C.E., F.G.S.*

THE subject matter of the department of the British Association over which I have on this occasion been called to preside is that of Mechanics; and although, properly speaking, this department embraces within its confines the whole of the vast range of mechanical philosophy, extending from the infinitely great of the universe, down to the infinitely small of the ultimate atom, yet, as I apprehend, it is our more immediate purpose to limit our inquiries for the most part, if not altogether, to those branches of Statics and Dynamics which are or may be employed for the realisation of so-called "practical ends," I now offer for consideration a few thoughts with regard to the unhappy necessity which the events of the last few years have only too sadly established, for devoting much of the science and skill of the members of the Association to the defence of the homes of the people of this great nation. Whatever may have been the advancement which civilized people have made in the arts of peace, it is only too evident that those people have even outstripped themselves in advancing the arts of destruction. We have seen in the great internal contention of our American brethren, and still later in the struggle in which several of the most important states of Europe have engaged, that war is no longer carried on by means of mere animal courage and brute force. On the contrary, we perceive, much to our amazement, I believe, that the highest branches of mechanical science and the most refined processes and operations of the mechanical arts are resorted to by the modern warrior for the purposes of offence and defence; and we are taught by the logic of facts that the modern soldier must cease to remain a passive machine, but, on the contrary, must henceforth be trained as a skilled labourer, if not, indeed, even as a skilled artisan. At the present moment the defences of this country are in a most unsatisfactory condition. Many endeavours have been made, and much money, reckoned by millions, has been expended, for the most part uselessly, in endeavours to secure our coasts against the attacks of a foreign enemy. Forts have been erected where an adversary would never seek to land. Ships of an enormous size, and carrying enormous armaments, have been constructed, which can neither sail on shallow waters, nor safely encounter a hurricane in deeper ones, which, with vast mechanical power on board, can yet not carry a sufficient quantity of coal to enable them to find their way to, and act as protectors of, our colonies, and which, for the same reason, are wholly unable to convey our merchantmen to those distant climes, without a safe communication with which the trade and commerce of England must be annihilated. Arsenals have been enlarged, if not constructed, in situations in which they can only be secured from an enemy's fire by fortifications which it will require an additional army to man. Guns, each one larger or more elaborate than the last, have been invented and constructed and tried, and floating castles, each one heavier and uglier and more unmanageable and more useless, except for special applications, than the former one, have been built and cast upon the waters to resist them, and yet nearly all naval and military officers acknowledge that this

great country is not in a position to defend either herself or her colonies against a combined attack from more than one of those foreign friends we have heretofore recognized under a different appellation. It is a function of this department of our Association to study and discuss the forms of ships suitable for the purposes of commerce and war, to ascertain the conditions under which they will attain the highest velocities, or carry the heaviest burdens, to know and define the laws of resistance to motion in water (a subject to which I have devoted a not altogether useless attention), and to apply the motive force necessary to overcome that resistance in the most economical, most convenient, and most serviceable manner; and it is also a function of this department to deal with the theory and practice of projectiles, and to contrive the means by which these warlike instruments, both large and small, may be most advantageously employed by our military and naval forces. But whilst, as good Englishmen, we feel the necessity of being prepared for war in order to secure a lasting and respected peace, we must not neglect the consideration of so much more of our science as contributes to the material wealth and prosperity of our country, and to the social comfort and intellectual improvement of its inhabitants, and, I may add, of the whole world. Before sitting down, permit me to request your attention to the many points of interest peculiar to this town and its neighbourhood. You will find here, in the lace-machine, combinations and arrangements of mechanism of the most complicated yet of the most exact kind, all tending to the cheap and rapid fabrication of an article of commerce, which has made its way over the entire world, and without the possession of which no home, and I had almost said no lady's dress, can be considered complete. The present state and extent of this really wonderful manufacture is an instance, and a remarkable one, of the effect of that law of continuity which last evening formed the staple of our President's address. It has only been by little and little, but by slow and continuous progression, that the lace mechanism of Nottingham has become developed into that condition of almost perfection to which it has now attained. The excursionists will find in the geology of this district much to invite their attention. Within a very few miles many of the most interesting formations of the earth's crust come to the surface, from the syenite at the base of the system to the more recent deposits of lias and oolite. Coal and ironstone are very abundant; and although it is to be regretted that the town of Nottingham has not yet availed itself of the vast amount of mineral wealth within its reach, yet, in the large undertakings of Butterly, Riddings, and other places, as well as the great extent to which the Midland Coalfield is being wrought for the supply of distant countries, you will see evidences of the growth of a local industry, which, as I believe, is yet in its infancy.

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*On the Application of the Expansive Power of moistened Vegetable Matter to the raising of Weights.* *By* Admiral Sir E. Belcher.

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*On a System of Pneumatic Propulsion.*
*By* M. Bergeron, *Manager of the Swiss Western Railways.*

The author proposes to propel the carriages through a tube by means of a column of air, and not to use exhaustion. This column of air he derives from the gradual sinking of a large bell, or succession of bells, after the manner of a gasholder. The raising of the bells will be effected by means of the direct action of hydraulic power from an elevated head, where such is available, and in any case the power, whether water or steam, used for raising the bell is only auxiliary, as the ascending carriages will drive the air before them, and thus raise the bell a certain portion of the necessary elevation. M. Bergeron is about to construct a short line on this system at Lausanne, for connecting that town with the terminus of the present railway there. The tube is to be constructed of concrete, the materials for which can be obtained at a low cost.

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*On the Action and Effect of Flame in Marine Boilers.* *By* N. P. Burgh.

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*On an Hydraulic Coal-cutting Machine.* *By* W. E. Garrett.

The machine, by means of a series of ingenious mechanical arrangements, is capable of being most readily adjusted and moved to suit the various conditions under which it is required to be used in the pit; and these could only be made intelligible by means of elaborate diagrams or inspection of the machine itself, or the model. The principle on which the machine works is that of the planing and slotting machine, the cutters acting by direct continuous pressure derived from a column of water, and not by blows. The machine has been in successful operation for more than two years.

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*On the Counterbalancing of Winding Engines for Coal Mines.*
*By* John Daglish.

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*On Steam-Boiler Explosions, with Suggestions for their Investigation.*
*By* H. Dircks.

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*Description of the Means employed for removing and replacing in a new position the Iron Columns of a Fireproof Cotton Mill.* *By* William Fairbairn, *LL.D., F.R.S.*

The improvements that have been effected in the machinery for spinning cotton have given rise to new conditions, new buildings, and new appliances to meet the numerous changes that have taken place. The machinery for carding, roving, and spinning has been renewed three different times within a period of less than sixty years, the old machines having been three times removed to give place to others of a more improved construction. The old narrow buildings of former days have consequently proved unequal to present wants, and it has been necessary either to alter the old mills to suit the new machinery, or to build new ones. The latter plan was occasionally preferred; but more frequently the spinning-rooms of the old mills were converted to the new mules, which from their increased number of spindles had to be fixed in the longitudinal direction, instead of transversely as formerly.

Immediately after the invention of the mule by Crompton, or about the commencement of the present century, a cotton-mill 45 feet in width was considered of proper dimensions for mules of 350 to 400 spindles. Two of these mules were looked upon for many years as the correct number for one man to work; and this might have been continued for a longer period, but for the invention of the self-acting mule by the late Mr. Roberts and others, which gave a new impetus to the spinning process; and in place of 400 spindles, as formerly, the mules of the present day contain from 800 to 1000 spindles. This increase in the length of the mule requires a corresponding increase of width in the mill; and hence arose the tower-like form of modern cotton factories, varying from 90 to 100, and in some cases from 110 to 120 feet wide.

In the construction of modern mills no difficulty exists, as they are built to suit the machinery; whereas in adapting the old narrow buildings to the new mules, it was necessary to break up the old mules, and place the new ones in the opposite or longitudinal direction of the mill. In mills with wooden floors, this was easily accomplished by removing one row of columns to admit a pair of mules in the middle; but in fireproof buildings, constructed with iron beams and brick arches, the greatest possible care was necessary to be observed in effecting the desired alteration, as illustrated in the case forming the subject of the present paper, where 90 to 100 tons of arches and machinery had to be supported on two columns, or one bay, in a building eight stories high, the mill being kept working during the whole time the alterations were going on.

The objection to this operation on the part of the proprietors, Messrs. M'Connel and Co., was, that the columns could not be removed without cutting them, which might incur the danger of the floors above being "brought down by the run." Each column had, in fact, to be cut in two, taken entirely out and new ones substituted at the required distances apart. As the particulars may be useful

and interesting, the writer offers the following description of the process by which this object was successfully accomplished under his directions.

The factory which required one row of cast-iron columns in each story to be cut out and removed to a distance of 2 feet 8 inches, is a fireproof building, eight stories high. It extends for 160 feet along Union Street, Manchester, fronting the Rochdale Canal, and runs parallel with it as far as Murray Street, where it terminates with an angular wing to a further distance of 80 feet. The width of the mill is 45 feet, divided by two rows of columns of three equal spans of 15 feet each, as seen in the annexed sectional diagram, which shows the position of the columns, those cut out being represented by the dotted line *a* (fig. 1), and those which replaced them by the black line *b*. The columns indicated by the line *c* were not disturbed. The figures *d*, *e*, *f*, *g* represent the position of the mule spinning-machinery, for the admission of which the original columns in the position of the dotted

Fig. 1.

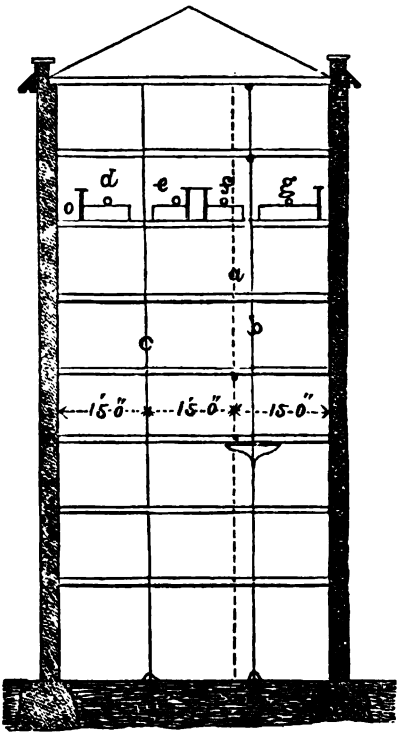
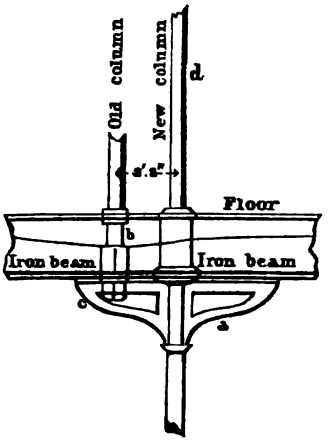



Fig. 2.




line had to be removed. The other mules next the side walls had quite sufficient room with the addition of the passage *o*, which extended along the side wall for the whole length of the mill.

In carrying out the process by which these alterations were effected the first consideration was, how to support the ends of the middle beams and arches during the process of removing the columns from under them; and also how to support the middle beam permanently after the columns had been removed. This could not be done simultaneously throughout the mill when at work, as it would have involved a very heavy expense to support the ends of all the middle beams at once, with a superincumbent weight on each of 90 tons of brick arches, and machinery. Moreover it was essential that only one pair of the old mules in each room should be stopped

at one time, and that only during the operation of fixing the new columns and cutting out the old ones.

The first thing to be done was therefore to prepare the new columns with projecting brackets (as shown in sketch), of sufficient length to reach beyond the ends of the wall beam *b* (fig. 2), so as to support the ends of the middle one after the old columns were removed. As it was impossible, however, to remove that part of the column which went through the beams, it was necessary first to fix the new columns under the wall beams in the line *d*, and subsequently to cut out the old ones at *c* progressively, as the work advanced from one end of the room to the other. The brackets on the new columns were made to project to about the same extent on both sides; but as they could not be extended the whole length on the side next the original columns, until the latter had been cut out and removed, the bracket intended for supporting the end of the middle beam at *c* was left 12 inches short, so as to leave sufficient space for attaching the apparatus for cutting out the old column; and a loose end was afterwards bolted to the bracket, and made to fit the stump end of the old column after it had been neatly cut off and removed, as shown in sketch at *c*.

The carrying out of this work was ably accomplished by the contractor, Mr. Andrew Ker; and in order to save time and labour, an apparatus was devised by him to take advantage of the shafts in motion, and thus to cut out the columns with great rapidity and success. The apparatus itself consists of two cast-iron clips embracing the column, and forming a table for supporting a spur-wheel, which revolves round the column and carries a steel cutter. The wheel is driven by a worm-shaft and pulley, which received motion from one of the driving-shafts in each room. The shank of the cutter is screwed to receive the rachet, and by means of a finger or peg the cutter receives the required advance, equivalent to the thickness of the cut every time the rachet passes the finger.

By this means the old columns were quickly cut out and removed, and the loose end of the bracket having been inserted, with two strong bolts, the end of the middle beam was thus supported with the same security as if the original columns had never been disturbed.

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*Improvement in Pontoon Trains.* *By* G. Fawcus, *North Shields.*

A complete pontoon train has been arranged to go either way or turn on its centre, with all the detailed fittings made reversible and interchangeable. This is a combination of a light and strong waggon-frame, with traversing frames between the wheels, where the beams and planks for forming the platform of a bridge are packed in separate compartments for simultaneous handling, and are secured there by a novel system of bolting, the load thus strengthening the carriage and increasing its stability. Above these frames the required number of inverted boats are packed.—See 'British Association Report of Transactions of Sections,' 1863, pp. 172, 173, article "Waggons and Boats" (Newcastle). In forming a bridge, the rowlocks on both gunwales form a double support for the beams, which are scarphed and keyed together with bolts and forelocks. The bolts are of an elliptical section, and fit into oblong holes and plates forming a rigid jointing.

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*On Locomotive Engines and Carriages on the Central Rail System for working Steep Gradients and Sharp Curves, as employed on the Mont Cenis.* *By* J. B. Fell.

It appeared that this work is proceeding most satisfactorily, and that it will probably be completed by the end of the year, and will be opened about May next. When this is done, the line of rail will be unbroken between Paris and Brindisi, on the Adriatic, from which port the Italian Government are running a line of steamers to Alexandria. Should our Government adopt this route for our Indian mails, as it is expected will be the case, instead of that of Marseilles, a saving of something like forty hours will be effected in their transmission between London and Alexandria. The works at Mont Cenis could be executed for £1000 per mile for the railway, and £250 per mile for permanent way; the stations would amount to another £1000 per mile, the rolling stock amounting to £750 per mile, the total

cost being £300,000. The tolls were high, being double those charged on an ordinary railway. Locomotive power for conveying passengers and goods over the mountain cost 1*s.* 4*d.* per passenger, and 4*s.* 8*d.* for each ton of goods. The total revenue was estimated to amount to £100,000 per annum. Assuming the traffic to increase at the rate of 10 per cent., the whole of the capital would be repaid within four years. The cost of this line would be only one-third that of a tunnel line. The working expenses would amount to 2 per cent. of the ordinary expenses. There would be no probability that the line would be choked with snow. About eight or nine miles of the line would be constructed in galleries some of masonry and some of wood.

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*An Invention for the Purpose of attaining greater Adhesion between the driving-wheel and the Rail. By* W. D. GAINSFORD.

The proposed plan consists merely in adding a second flange to the driving-wheel. The two flanges being closer together at the base than the middle of the rail, thus causing the weight of the wheels to be carried by the flanges pressing upon the sides of the rail instead of the face of the tire. The tractive power obtained by this means is $1\frac{1}{4}$ to $1\frac{1}{3}$ times the imposed weight.

As the flange is flat, and the rail, an ordinary double headed one, is round in section at the point where the tire touches it, the contact is little more than a point, and consequently there is no grinding between the flange and the rail, both becoming as bright and smooth as the face of an ordinary rail.

In passing round curves, the inner rail is laid with a narrower head, so that it falls to the bottom of the groove in the wheel, rendering the latter of a smaller diameter, and allowing it, if necessary, to slip, as in the ordinary railway wheel.

A locomotive was constructed upon this principle to run upon a colliery railway. Its weight was 20 cwt. loaded; 12 cwt. were borne by the driving-wheels, and 8 by the leading wheels.

The gradients experimented upon were 1 in 14 and 1 in 7. Less a gradient of 1 in 14 the engine drew a load, including wagons of 5 tons, at a speed of 3 miles per hour.

Less the gradient of 1 in 7 the engine drew a load of 35 cwt. at about the same speed.

The dimensions of the engine were: cylinder $3\frac{1}{2}$ inches diameter, 10 inches stroke; driving-wheels 12 inches diameter; highest steam pressure 120 lbs. to the inch.

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*Description of a Newly-invented System of Ordnance. By* W. D. GAINSFORD.

The projectile thrown by the proposed gun is a sharp-edged disk, formed by the junction, at the basis of the frusta, of two equal and similar cones. Each frustum is half the height of the original cone, and each cone is one-third its base diameter in height. Consequently, the major is three times the minor axis. The disk is fixed in an upright direction, and the rotation is upon the minor axis. To propel this projectile a gun is used, which internally consists of two parts, a chamber for the powder and the barrel or receptacle for the shot. The barrel is very short, so that when loaded the front of the disk is level with the mouth of the gun. Direction is given by the close fitting of the sides of the barrel to the disk, rotation by a pin passed through the barrel in a horizontal direction, in its lower part, so as to take hold in a notch cut in the edge of the disk. It is thus evident that the disk, on leaving the gun, will acquire a rotation equal in speed at the mouth to the speed of the disk itself where it last touches the catch. By putting the catch nearly under the centre of the disk, a speed of rotation of the periphery nearly equal to the initial velocity of the projectile would be obtained. As, however, much less than this will suffice to keep the axis of the disk at right angles to its line of motion, the catch is placed further back, and offers but little resistance to the exit of the projectile. Thus an efficient rotation is obtained without friction; and from the absence of friction great initial velocity is obtained; and the recoil being small, from the same reason, large charges of powder may be used. A long maintenance of the velocity is ensured by the shape and rotation of the disk, which is more adapted for retaining its velocity than a conical or bolt-

shaped shot. The recoil is small from the absence of friction, which in rifled guns amounts to from one-third to one-half the power employed. In the proposed gun the only recoil is that due to the simple propulsion of the shot. An experimental gun has been made on this principle, throwing a shot of 4 lb. 2 oz. The charged used was one-eleventh, or 6 oz. of powder. The first shot was fired from H.M.S. 'Cambridge,' the gunnery ship at Devonport, at the target in the creek, a distance of 1000 yards. The rotation was perfect, and the direction excellent. The gun was again fired from Bovicsand, Devonport, and gave a range of 2000 yards first graze with the same charge. Had the construction of the gun allowed a heavier charge of powder, no doubt a much greater range would have been obtained. Further experiments were prevented by the cracking of the gun at the muzzle.

*On the Chalmers Target.* *By* Captain Douglas Galton, *F.R.S.*, *F.G.S.*

The target may be understood by looking upon it as a beam, in which the top flange is the front plate, the bottom flange a thinner plate behind, these two flanges being kept apart by means of a web of plates at right angles to the flanges. These intermediate plates are supported laterally by layers of wood to prevent their breaking. The author stated that the results of the experiments made by the Iron Plate Committee had been most successful, and showed that the principle was correct.

*On the Electrical and Mechanical Properties of Hooper's India-rubber Insulated Wire for Submarine Cables.* *By* William Hooper.

The author described the method by which he secures the durability of his rubber. Its high degree of insulation was pointed out, and its durability under very trying conditions, over long periods of time, confirmed by experiments conducted by Sir Charles Bright, Capt. Mallock, and others. It was stated that Mr. Latimer Clark had found it unnecessary to ship Mr. Hooper's cables in water-tanks; and the Ceylon cable, now on its way out, is coiled dry. The inductive capacity of Mr. Hooper's wire remains practically the same at all temperatures, while that of gutta percha increases considerably at 100° Fahr. Diagrams, representing the effects of pressure and immersion, were shown, from which it was seen that pressure improves the insulation of his wire in the same way as is observed with gutta percha. The result of carefully conducted experiments, extending over three years, proves that the absorption of water is so small that the most refined electrical tests failed to discover it.

*On Rotary Engines, with special reference to one invented by W. Hall.* *By* G. O. Hughes.

*On recent Improvements in the Application of Concrete to Fireproof Constructions.* *By* Frederick Ingle.

The author pointed out what he considered a radical defect of concrete formed of lime, as ordinarily used, viz. that by the action of fire it becomes reconverted into lime, which, when the water from the engines is brought to bear upon it, expands greatly, and forces out the walls to the destruction of the building. He advocated the use of a concrete formed from gypsum, which is not liable to this defect. The gypsum, which is of a coarse and inexpensive character, is formed into plaster of Paris by roasting, and mixed with a peculiar kind of clay found in connexion with the beds of gypsum.

*On a New Arrangement for picking up Submarine Cables.* *By* Fleeming Jenkin, *F.R.S.*

This machinery was intended to limit and regulate the strain which could possibly be brought on a submarine cable or rope attached to it while being hauled on board by the ordinary drum driven by a steam-engine. During this operation it had hitherto been necessary to watch the cable carefully, regulating the speed of the engine so as to keep the strain, as shown by the dynamometer, below that

which was considered safe. It was further necessary to be ready, at an instant's warning, to stop the engine in case the cable fouled any part of the ship; and the author had seen a cable broken owing to the impossibilty of stopping the engine soon enough. Moreover, even when the above precautions were taken, it was impossible to avoid a considerable variation of strain, due to the pitching of the ship, which alternately slackened and lengthened the cable as it hung vertically; and in most cases in the author's experience cables, while being picked up in great depths, had broken from this cause. All these dangers were avoided by the machinery invented by the author, of which two models were shown. These two forms were identical in principle. A spur-wheel, fast on a main shaft, driven by the engine, geared into another spur-wheel centered in the periphery of a brake-drum, loose on the main shaft, and restrained from turning by an Appold's brake; the second spur-wheel in one form geared directly into an internal-toothed wheel bolted on the picking-up drum, which was also loose on the main shaft above mentioned. When the brake-drum was stationary, the engine simply drove the brake-drum through the spur-wheels in the ordinary manner; but when the strain on the cable reached the amount corresponding to that given by the weight restraining the brake-drum, the picking-up drum ceased to revolve, because the brake-drum turned instead, carrying round the second or intermediate spur-wheel, which rolled inside the internal-toothed wheel, instead of driving it; the centre on which this intermediate spur-wheel worked might be looked on as a fulcrum, and the wheel itself as a lever, by which the engine pushed round the picking-up drum: if the fulcrum yielded, the weight could not be lifted. The second form of model was exactly similar in principle. A second intermediate wheel, of different diameter, fast on the same shaft as the first, geared into an external-toothed spur-wheel connected with the picking-up drum. The action was identical with that already described. If the strain increased beyond that required to stop the picking-up drum, it would turn in the other direction, and the cable would be paid out instead of picked up, although the engine would continue to run in the same direction as before, and exerted the same power. In practice, as was shown by the models, the engine might be driven at any speed; the cable would only be subject to the strain chosen, which might be increased or diminished at will; it would come up quicker or slower as the ship fell or rose; it would stop wholly if the cable fouled; it would be paid out if, from inattention, the ship drifted out of position, or from any other cause the strain increased on the cable. More than this, the cable might actually be paid out as the ship rose, and picked up as it fell, and the whole would take place with perfect smoothness and constancy of strain. The Appold brake gave a constant restraining power to the brake-drum, whatever the coefficient of friction might be. The gear exhibited formed at once a paying-out and picking-up machine. It might be termed an accurate slip-coupling, and could be applied to many purposes—as, for instance, to the measurement of steam power let out. With one of these couplings on the transmitting shaft, it would be impossible to overload the shaft. Similarly, the coupling would serve to prevent a break-down in cases where the machinery was liable to sudden starts or stoppages. It would prevent undue strains on the ropes of collieries and lifts, and other applications would readily occur to mechanical men.

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*On Zinc Sheathing for Ships.* *By* SAMUEL J. MACKIE, *F.G.S.*

Iron ships are subjected to a great amount of corrosion, and are so liable to foul, that sailing-ships of iron cannot be sent on long voyages. Copper sheathing, or Muntz's metal, cannot be applied to iron ships as it is to wooden ones, because the iron being positive to copper, electrical action would be set up, by which the iron would be destroyed at a greatly increased rate. If, then, a metal were found which should be positive to iron, when the two metals were in contact in sea-water, the conditions of the voltaic battery formed by the iron ship and its sheathing would be reversed, and the sheathing would be destroyed while the iron would be preserved. A further condition was required to be satisfied, namely, that the metal forming the sheathing should not be destroyed too quickly, but only sufficiently to prevent the growth of animal and vegetable parasites by the " but constant scaling of the surface. Such a metal was zinc, the cost of which

was about two-thirds that of copper, and the electro-chemical action upon it was not only so slow as not to exceed the action of salt water upon the copper sheathing on a wooden vessel, but this action it was possible to control within certain limits. These results have been confirmed by careful experiments made under the direction of the Admiralty at Portsmouth, where zinc-sheathed iron plates had been submerged for eighteen months, and had been taken up bright and clear of any kind of fouling whatever. The method had been invented and patented by Mr. T. B. Daft, C.E., who had also devised a plan for the construction of iron ships, by which, instead of close-fitting butt-joints, the plates were lap-jointed on to a back strap, with an intervening space of about an inch wide, which was filled with a caulking of compressed teak, into which the nails were driven for fastening the zinc sheathing to the hull of the ship. By this plan of construction a flush surface was obtained, while the strength of the ship would be increased, and as fouling would be entirely prevented by the zinc sheathing, iron ships could hereafter be sent on the longest voyages. One of the commercial results of this application of that sheathing would therefore be the doubling of the iron ship-building trade through the demand for iron instead of wooden sailing-vessels.

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*On the Treatment of melted Cast Iron and its Conversion into Iron and and Steel by the Pneumatic Process.* *By* R. Mushet.

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*On the Theory of the Influence of Friction upon the Mechanical Efficiency of Steam.* *By* Prof. W. J. Macquorn Rankine, *LL.D., F.R.SS. L. & E.*

The results arrived at by the author of this paper are based on the following principle. Let W be the indicated work of a given quantity of steam, without deducting loss by friction, and H the mechanical equivalent of the expenditure of heat required in order to do that work; so that $W \div H$ is the efficiency of the steam without friction. Let F be the quantity of work lost through friction in the cylinder; and let the heat produced by that friction be wholly taken up by the steam. Then the work done is diminished to $W - F$, and the heat expended is diminished to $H - F$; so that the efficiency becomes $\frac{W-F}{H-F}$. The special way in which the friction takes effect in ordinary steam-engines is by diminishing the expenditure of heat required for the prevention of liquefaction in the cylinder.

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*Remarks on the Experiments of the Committee upon the Resistance of Water to Floating and Immersed Bodies.* *By* Prof. W. J. Macquorn Rankine, *LL.D., F.R.SS. L. & E.*

The author said that his object in reading the present paper was not so much to bring forward any opinions of his own as to open the way for a discussion on the subject of the resistance of water to bodies passing through it. The custom of the Association was that a Report should be discussed; and, therefore, when it was desired to hold a discussion on the subject of a Report, it became necessary to read a communication from some individual on the same subject. With respect to the experiments recorded in the Report, he would observe that they formed a body of facts which were available for every inquirer to reduce in his own way. From a brief investigation of their results, by the aid of graphic projection, he believed that the following conclusions might safely be drawn:—

1. That agreeably to what was previously known as to the resistance of water to the motions of bodies of small dimensions at low speeds, the resistance increased, on the whole, somewhat more slowly than the square of the velocity.

2. That when the velocity went beyond the maximum velocity suited to the length, according to Mr. Scott Russell's rule (that is to say, about $3\frac{1}{2}$ ft. per second, the models being 4 ft. long), the resistance showed a tendency to increase at a more rapid rate, and the water became so much disturbed by waves as to make it difficult, and sometimes impracticable, to continue the experiments.

3. That while the midship section of model A was to that of model B as 1·57

to 1, and the mean girth of model A was to that of model B as 1·45 to 1, the resistance of model A was to that of model B in a somewhat less ratio than the latter proportion, though not very much less at moderate speeds.

4. That the resistance of model A, when just covered with water, was almost exactly double of its resistance at the same speed when half immersed.

5. That the resistance of model B, when immersed to about three-and-a-half times its depth, was sensibly more than double its resistance when half immersed.

The author adverted to the great mass of detailed information as to the propulsion of vessels which had been accumulated by the late Committee on Steamship performance; and stated his opinion that much good might be done by digesting and condensing that information, which at present was in a form too voluminous for practical use.

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*On Barytic Powder for Heavy Ordnance. By* Captain WYNANTS, *of the Royal Belgian Artillery. Communicated by* CHARLES VIGNOLES., *F.R.S., M.R.I.A.*

This particular kind of powder has been much experimented upon, both in Belgium and in France, with a view to counteract the injurious effect which is produced when large charges of powder are used in heavy ordnance. The principle on which this barytic powder is compounded is simply that of substituting nitrate of barytes in the composition of the gunpowder, instead of saltpetre, in certain proportions, the consequence being that the powder, when ignited, consumes more slowly, and the gases are developed less rapidly than in ordinary gunpowder, while the same effect is produced upon the projectile as regards its ultimate velocity. This lessens the injurious effect upon the sides, vent, and chamber of the piece of artillery. Capt. Wynants entered into the details of a very large number of experiments made with this powder. The general result to be deduced from these experiments is, that we have to choose between imparting a higher degree of velocity to the projectile, at the risk of damaging the piece more rapidly and more considerably, or confining our attention to the American plan of projecting heavier shot at a lower velocity. The preponderating feeling in the minds of English engineers and artillerists, and particularly of sailors, is for a higher degree of velocity, with a smaller weight of shot. The question is an exceedingly interesting one, and has excited considerable attention both in Belgium and in France, as it has done in Prussia and America. If these experiments could be continued, we should obtain some very useful information on the subject. Capt. Wynants considered that the principal difficulty in dealing with the present enormous artillery arose from the too rapid consumption of the powder, by which the generation of gas was so rapid that the interior of the gun was destructively affected before the projectile was moved. Capt. Wynants found that by substituting nitrate of barytes for saltpetre in the composition of gunpowder the rapidity of the combustion was reduced without the propelling force of the powder being diminished—in fact, the propelling force was rendered more uniform in its action.

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CONTENTS:—Report of the Committee appointed to conduct the cooperation of the British Association in the System of Simultaneous Magnetical and Meteorological Observations;—J. Richardson, M.D., Report on the present State of the Ichthyology of New Zealand;—W. S. Harris, Report on the Progress of Meteorological Observations at Plymouth;—Second Report of a Committee appointed to make Experiments on the Growth and Vitality of Seeds;—C. Vignoles, Report of the Committee on Railway Sections;—Report of the Committee for the Preservation of Animal and Vegetable Substances;—Lyon Playfair, M.D., Abstract of Prof. Liebig's Report on Organic Chemistry applied to Physiology and Pathology;—R. Owen, Report on the British Fossil Mammalia, Part I.;—R. Hunt, Researches on the Influence of Light on the Germination of Seeds and the Growth of Plants;—L. Agassiz, Report on the Fossil Fishes of the Devonian System or Old Red Sandstone;—W. Fairbairn, Appendix to a Report on the Strength and other Properties of Cast Iron obtained from the Hot and Cold Blast;—D. Milne, Report of the Committee for Registering Shocks of Earthquakes in Great Britain;—Report of a Committee on the construction of a Constant Indicator for Steam-Engines, and for the determination of the Velocity of the Piston of the Self-acting Engine at different periods of the Stroke;—J. S. Russell, Report of a Committee on the Form of Ships;—Report of a Committee appointed "to consider of the Rules by which the Nomenclature of Zoology may be established on a uniform and permanent basis;"—Report of a Committee on the Vital Statistics of large Towns in Scotland;—Provisional Reports, and Notices of Progress in special Researches entrusted to Committees and Individuals.

Together with the Transactions of the Sections, Lord Francis Egerton's Address, and Recommendations of the Association and its Committees.

## PROCEEDINGS OF THE THIRTEENTH MEETING, at Cork, 1843, *Published at* 12*s.*

CONTENTS:—Robert Mallet, Third Report upon the Action of Air and Water, whether fresh or salt, clear or foul, and at Various Temperatures, upon Cast Iron, Wrought Iron, and Steel;—Report of the Committee appointed to conduct the cooperation of the British Association in the System of Simultaneous Magnetical and Meteorological Observations;—Sir J. F. W. Herschel, Bart., Report of the Committee appointed for the Reduction of Meteorological Observations;—Report of the Committee appointed for Experiments on Steam-Engines;—Report of the Committee appointed to continue their Experiments on the Vitality of Seeds;—J. S. Russell, Report of a Series of Observations on the Tides of the Frith of Forth and the East Coast of Scotland;—J. S. Russell, Notice of a Report of the Committee on the Form of Ships;—J. Blake, Report on the Physiological Action of Medicines;—Report of the Committee on Zoological Nomenclature;—Report of the Committee for Registering the Shocks of Earthquakes, and making such Meteorological Observations as may appear to them desirable;—Report of the Committee for conducting Experiments with Captive Balloons;—Prof. Wheatstone, Appendix to the Report;—Report of the Committee for the Translation and Publication of Foreign Scientific Memoirs;—C. W. Peach, on the Habits of the Marine Testacea;—E. Forbes, Report on the Mollusca and Radiata of the Ægean Sea, and on their distribution, considered as bearing on Geology;—L. Agassiz, Synoptical Table of British Fossil Fishes, arranged in the order of the Geological Formations;—R. Owen, Report on the British Fossil Mammalia, Part II.;—E. W. Binney, Report on the excavation made at the ction of the Lower New Red Sandstone with the Coal Measures at Collyhurst;—W.

Thompson, Report on the Fauna of Ireland: Div. *Invertebrata*;—Provisional Reports, and Notices of Progress in Special Researches entrusted to Committees and Individuals.

Together with the Transactions of the Sections, Earl of Rosse's Address, and Recommendations of the Association and its Committees.

## PROCEEDINGS OF THE FOURTEENTH MEETING, at York, 1844, *Published at* £1.

CONTENTS:—W. B. Carpenter, on the Microscopic Structure of Shells;—J. Alder and A. Hancock, Report on the British Nudibranchiate Mollusca;—R. Hunt, Researches on the Influence of Light on the Germination of Seeds and the Growth of Plants;—Report of a Committee appointed by the British Association in 1840, for revising the Nomenclature of the Stars;—Lt.-Col. Sabine, on the Meteorology of Toronto in Canada;—J. Blackwall, Report on some recent researches into the Structure, Functions, and Economy of the *Araneidea* made in Great Britain;—Earl of Rosse, on the Construction of large Reflecting Telescopes;—Rev. W. V. Harcourt, Report on a Gas-furnace for Experiments on Vitrifaction and other Applications of High Heat in the Laboratory;—Report of the Committee for Registering Earthquake Shocks in Scotland;—Report of a Committee for Experiments on Steam-Engines;—Report of the Committee to investigate the Varieties of the Human Race;—Fourth Report of a Committee appointed to continue their Experiments on the Vitality of Seeds;—W. Fairbairn, on the Consumption of Fuel and the Prevention of Smoke;—F. Ronalds, Report concerning the Observatory of the British Association at Kew;—Sixth Report of the Committee appointed to conduct the Cooperation of the British Association in the System of Simultaneous Magnetical and Meteorological Observations;—Prof. Forchhammer on the influence of Fucoidal Plants upon the Formations of the Earth, on Metamorphism in general, and particularly the Metamorphosis of the Scandinavian Alum Slate;—H. E. Strickland, Report on the recent Progress and Present State of Ornithology;—T. Oldham, Report of Committee appointed to conduct Observations on Subterranean Temperature in Ireland;—Prof. Owen, Report on the Extinct Mammals of Australia, with descriptions of certain Fossils indicative of the former existence in that continent of large Marsupial Representatives of the Order Pachydermata;—W. S. Harris, Report on the working of Whewell and Osler's Anemometers at Plymouth, for the years 1841, 1842, 1843;—W. R. Birt, Report on Atmospheric Waves;—L. Agassiz, Rapport sur les Poissons Fossiles de l'Argile de Londres, with translation;—J. S. Russell, Report on Waves;—Provisional Reports, and Notices of Progress in Special Researches entrusted to Committees and Individuals.

Together with the Transactions of the Sections, Dean of Ely's Address, and Recommendations of the Association and its Committees.

## PROCEEDINGS OF THE FIFTEENTH MEETING, at Cambridge, 1845, *Published at* 12*s*.

CONTENTS:—Seventh Report of a Committee appointed to conduct the Cooperation of the British Association in the System of Simultaneous Magnetical and Meteorological Observations;—Lt.-Col. Sabine, on some points in the Meteorology of Bombay;—J. Blake, Report on the Physiological Actions of Medicines;—Dr. Von Boguslawski, on the Comet of 1843;—R. Hunt, Report on the Actinograph;—Prof. Schönbein, on Ozone;—Prof. Erman, on the Influence of Friction upon Thermo-Electricity;—Baron Senftenberg, on the Self-Registering Meteorological Instruments employed in the Observatory at Senftenberg;—W. R. Birt, Second Report on Atmospheric Waves;—G. R. Porter, on the Progress and Present Extent of Savings' Banks in the United Kingdom;—Prof. Bunsen and Dr. Playfair, Report on the Gases evolved from Iron Furnaces, with reference to the Theory of Smelting of Iron;—Dr. Richardson, Report on the Ichthyology of the Seas of China and Japan;—Report of the Committee on the Registration of Periodical Phenomena of Animals and Vegetables;—Fifth Report of the Committee on the Vitality of Seeds;—Appendix, &c.

Together with the Transactions of the Sections, Sir J. F. W. Herschel's Address, and Recommendations of the Association and its Committees.

## PROCEEDINGS OF THE SIXTEENTH MEETING, at Southampton, 1846, *Published at* 15*s*.

CONTENTS:—G. G. Stokes, Report on Recent Researches in Hydrodynamics;—Sixth Report of the Committee on the Vitality of Seeds;—Dr. Schunck on the Colouring Matters of Madder;—J. Blake, on the Physiological Action of Medicines;—R. Hunt, Report on the Actinograph;—R. Hunt, Notices on the Influence of Light on the Growth of Plants;—R. L. Ellis, on the Recent Progress of Analysis;—Prof. Forchhammer, on Comparative Analytical

Researches on Sea Water;—A. Erman, on the Calculation of the Gaussian Constants for 1829;—G. R. Porter, on the Progress, present Amount, and probable future Condition of the Iron Manufacture in Great Britain;—W. R. Birt, Third Report on Atmospheric Waves;—Prof. Owen, Report on the Archetype and Homologies of the Vertebrate Skeleton;—J. Phillips, on Anemometry;—J. Percy, M.D., Report on the Crystalline Flags;—Addenda to Mr. Birt's Report on Atmospheric Waves.

Together with the Transactions of the Sections, Sir R. I. Murchison's Address, and Recommendations of the Association and its Committees.

## PROCEEDINGS OF THE SEVENTEENTH MEETING, at Oxford, 1847, *Published at* 18*s*.

CONTENTS:—Prof. Langberg, on the Specific Gravity of Sulphuric Acid at different degrees of dilution, and on the relation which exists between the Development of Heat and the coincident contraction of Volume in Sulphuric Acid when mixed with Water;—R. Hunt, Researches on the Influence of the Solar Rays on the Growth of Plants;—R. Mallet, on the Facts of Earthquake Phenomena;—Prof. Nilsson, on the Primitive Inhabitants of Scandinavia;—W. Hopkins, Report on the Geological Theories of Elevation and Earthquakes;—Dr. W. B. Carpenter, Report on the Microscopic Structure of Shells;—Rev. W. Whewell and Sir James C. Ross, Report upon the Recommendation of an Expedition for the purpose of completing our knowledge of the Tides;—Dr. Schunck, on Colouring Matters;—Seventh Report of the Committee on the Vitality of Seeds;—J. Glynn, on the Turbine or Horizontal Water-Wheel of France and Germany;—Dr. R. G. Latham, on the present state and recent progress of Ethnographical Philology;—Dr. J. C. Prichard, on the various methods of Research which contribute to the Advancement of Ethnology, and of the relations of that Science to other branches of Knowledge;—Dr. C. C. J. Bunsen, on the results of the recent Egyptian researches in reference to Asiatic and African Ethnology, and the Classification of Languages;—Dr. C. Meyer, on the Importance of the Study of the Celtic Language as exhibited by the Modern Celtic Dialects still extant;—Dr. Max Müller, on the Relation of the Bengali to the Arian and Aboriginal Languages of India;—W. R. Birt, Fourth Report on Atmospheric Waves;—Prof. W. H. Dove, Temperature Tables, with Introductory Remarks by Lieut.-Col. E. Sabine;—A. Erman and H. Petersen, Third Report on the Calculation of the Gaussian Constants for 1829.

Together with the Transactions of the Sections, Sir Robert Harry Inglis's Address, and Recommendations of the Association and its Committees.

## PROCEEDINGS OF THE EIGHTEENTH MEETING, at Swansea, 1848, *Published at* 9*s*.

CONTENTS:—Rev. Prof. Powell, A Catalogue of Observations of Luminous Meteors;—J. Glynn on Water-pressure Engines;—R. A. Smith, on the Air and Water of Towns;—Eighth Report of Committee on the Growth and Vitality of Seeds;—W. R. Birt, Fifth Report on Atmospheric Waves;—E. Schunck, on Colouring Matters;—J. P. Budd, on the advantageous use made of the gaseous escape from the Blast Furnaces at the Ystalyfera Iron Works;—R. Hunt, Report of progress in the investigation of the Action of Carbonic Acid on the Growth of Plants allied to those of the Coal Formations;—Prof. H. W. Dove, Supplement to the Temperature Tables printed in the Report of the British Association for 1847;—Remarks by Prof. Dove on his recently constructed Maps of the Monthly Isothermal Lines of the Globe, and on some of the principal Conclusions in regard to Climatology deducible from them; with an introductory Notice by Lt.-Col. E. Sabine;—Dr. Daubeny, on the progress of the investigation on the Influence of Carbonic Acid on the Growth of Ferns;—J. Phillips, Notice of further progress in Anemometrical Researches;—Mr. Mallet's Letter to the Assistant-General Secretary;—A. Erman, Second Report on the Gaussian Constants;—Report of a Committee relative to the expediency of recommending the continuance of the Toronto Magnetical and Meteorological Observatory until December 1850.

Together with the Transactions of the Sections, the Marquis of Northampton's Address, and Recommendations of the Association and its Committees.

## PROCEEDINGS OF THE NINETEENTH MEETING, at Birmingham, 1849, *Published at* 10*s*.

CONTENTS:—Rev. Prof. Powell, A Catalogue of Observations of Luminous Meteors;—Earl of Rosse, Notice of Nebulæ lately observed in the Six-feet Reflector;—Prof. Daubeny, on the Influence of Carbonic Acid Gas on the health of Plants, especially of those allied to the Fossil Remains found in the Coal Formation;—Dr. Andrews, Report on the Heat of Combination;—Report of the Committee on the Registration of the Periodic Phenomena of Plants and

Animals;—Ninth Report of Committee on Experiments on the Growth and Vitality of Seeds;—F. Ronalds, Report concerning the Observatory of the British Association at Kew, from Aug. 9, 1848 to Sept. 12, 1849;—R. Mallet, Report on the Experimental Inquiry on Railway Bar Corrosion;—W. R. Birt, Report on the Discussion of the Electrical Observations at Kew.

Together with the Transactions of the Sections, the Rev. T. R. Robinson's Address, and Recommendations of the Association and its Committees.

## PROCEEDINGS OF THE TWENTIETH MEETING, at Edinburgh, 1850, *Published at* 15*s*.

CONTENTS:—R. Mallet, First Report on the Facts of Earthquake Phenomena;—Rev. Prof. Powell, on Observations of Luminous Meteors;—Dr. T. Williams, on the Structure and History of the British Annelida;—T. C. Hunt, Results of Meteorological Observations taken at St. Michael's from the 1st of January, 1840 to the 31st of December, 1849;—R. Hunt, on the present State of our Knowledge of the Chemical Action of the Solar Radiations;—Tenth Report of Committee on Experiments on the Growth and Vitality of Seeds;—Major-Gen. Briggs, Report on the Aboriginal Tribes of India;—F. Ronalds, Report concerning the Observatory of the British Association at Kew;—E. Forbes, Report on the Investigation of British Marine Zoology by means of the Dredge;—R. MacAndrew, Notes on the Distribution and Range in depth of Mollusca and other Marine Animals, observed on the coasts of Spain, Portugal, Barbary, Malta, and Southern Italy in 1849;—Prof. Allman, on the Present State of our Knowledge of the Freshwater Polyzoa;—Registration of the Periodical Phenomena of Plants and Animals;—Suggestions to Astronomers for the Observation of the Total Eclipse of the Sun on July 28, 1851.

Together with the Transactions of the Sections, Sir David Brewster's Address, and Recommendations of the Association and its Committees.

## PROCEEDINGS OF THE TWENTY-FIRST MEETING, at Ipswich, 1851, *Published at* 16*s*. 6*d*.

CONTENTS:—Rev. Prof. Powell, on Observations of Luminous Meteors;—Eleventh Report of Committee on Experiments on the Growth and Vitality of Seeds;—Dr. J. Drew, on the Climate of Southampton;—Dr. R. A. Smith, on the Air and Water of Towns: Action of Porous Strata, Water and Organic Matter;—Report of the Committee appointed to consider the probable Effects in an Economical and Physical Point of View of the Destruction of Tropical Forests;—A. Henfrey, on the Reproduction and supposed Existence of Sexual Organs in the Higher Cryptogamous Plants;—Dr. Daubeny, on the Nomenclature of Organic Compounds;—Rev. Dr. Donaldson, on two unsolved Problems in Indo-German Philology;—Dr. T. Williams, Report on the British Annelida;—R. Mallet, Second Report on the Facts of Earthquake Phenomena;—Letter from Prof. Henry to Col. Sabine, on the System of Meteorological Observations proposed to be established in the United States;—Col. Sabine, Report on the Kew Magnetographs;—J. Welsh, Report on the Performance of his three Magnetographs during the Experimental Trial at the Kew Observatory;—F. Ronalds, Report concerning the Observatory of the British Association at Kew, from September 12, 1850 to July 31, 1851;—Ordnance Survey of Scotland.

Together with the Transactions of the Sections, Prof. Airy's Address, and Recommendations of the Association and its Committees.

## PROCEEDINGS OF THE TWENTY-SECOND MEETING, at Belfast, 1852, *Published at* 15*s*.

CONTENTS:—R. Mallet, Third Report on the Facts of Earthquake Phenomena;—Twelfth Report of Committee on Experiments on the Growth and Vitality of Seeds;—Rev. Prof. Powell, Report on Observations of Luminous Meteors, 1851–52;—Dr. Gladstone, on the Influence of the Solar Radiations on the Vital Powers of Plants;—A Manual of Ethnological Inquiry;—Col. Sykes, Mean Temperature of the Day, and Monthly Fall of Rain at 127 Stations under the Bengal Presidency;—Prof. J. D. Forbes, on Experiments on the Laws of the Conduction of Heat;—R. Hunt, on the Chemical Action of the Solar Radiations;—Dr. Hodges, on the Composition and Economy of the Flax Plant;—W. Thompson, on the Freshwater Fishes of Ulster;—W. Thompson, Supplementary Report on the Fauna of Ireland;—W. Wills, on the Meteorology of Birmingham;—J. Thomson, on the Vortex-Water-Wheel;—J. B. Lawes and Dr. Gilbert, on the Composition of Foods in relation to Respiration and the Feeding of Animals.

Together with the Transactions of the Sections, Colonel Sabine's Address, and Recommendations of the Association and its Committees.

## PROCEEDINGS OF THE TWENTY-THIRD MEETING, at Hull, 1853, *Published at* 10*s.* 6*d.*

CONTENTS:—Rev. Prof. Powell, Report on Observations of Luminous Meteors, 1852–53; —James Oldham, on the Physical Features of the Humber;—James Oldham, on the Rise, Progress, and Present Position of Steam Navigation in Hull;—William Fairbairn, Experimental Researches to determine the Strength of Locomotive Boilers, and the causes which lead to Explosion;—J. J. Sylvester, Provisional Report on the Theory of Determinants;—Professor Hodges, M.D., Report on the Gases evolved in Steeping Flax, and on the Composition and Economy of the Flax Plant;—Thirteenth Report of Committee on Experiments on the Growth and Vitality of Seeds;—Robert Hunt, on the Chemical Action of the Solar Radiations; —John P. Bell, M.D., Observations on the Character and Measurements of Degradation of the Yorkshire Coast; First Report of Committee on the Physical Character of the Moon's Surface, as compared with that of the Earth;—R. Mallet, Provisional Report on Earthquake Wave-Transits; and on Seismometrical Instruments;—William Fairbairn, on the Mechanical Properties of Metals as derived from repeated Meltings, exhibiting the maximum point of strength and the causes of deterioration;—Robert Mallet, Third Report on the Facts of Earthquake Phenomena (continued).

Together with the Transactions of the Sections, Mr. Hopkins's Address, and Recommendations of the Association and its Committees.

## PROCEEDINGS OF THE TWENTY-FOURTH MEETING, at Liverpool, 1854, *Published at* 18*s.*

CONTENTS:—R. Mallet, Third Report on the Facts of Earthquake Phenomena (continued); —Major-General Chesney, on the Construction and General Use of Efficient Life-Boats;—Rev. Prof. Powell, Third Report on the present State of our Knowledge of Radiant Heat;—Colonel Sabine, on some of the results obtained at the British Colonial Magnetic Observatories;—Colonel Portlock, Report of the Committee on Earthquakes, with their proceedings respecting Seismometers;—Dr. Gladstone, on the influence of the Solar Radiations on the Vital Powers of Plants, Part 2;—Rev. Prof. Powell, Report on Observations of Luminous Meteors, 1853–54; —Second Report of the Committee on the Physical Character of the Moon's Surface;—W. G. Armstrong, on the Application of Water-Pressure Machinery;—J. B. Lawes and Dr. Gilbert, on the Equivalency of Starch and Sugar in Food;—Archibald Smith, on the Deviations of the Compass in Wooden and Iron Ships;—Fourteenth Report of Committee on Experiments on the Growth and Vitality of Seeds.

Together with the Transactions of the Sections, the Earl of Harrowby's Address, and Recommendations of the Association and its Committees.

## PROCEEDINGS OF THE TWENTY-FIFTH MEETING, at Glasgow, 1855, *Published at* 15*s.*

CONTENTS:—T. Dobson, Report on the Relation between Explosions in Coal-Mines and Revolving Storms;—Dr. Gladstone, on the Influence of the Solar Radiations on the Vital Powers of Plants growing under different Atmospheric Conditions, Part 3;—C. Spence Bate, on the British Edriophthalma;—J. F. Bateman, on the present state of our knowledge on the Supply of Water to Towns;—Fifteenth Report of Committee on Experiments on the Growth and Vitality of Seeds;—Rev. Prof. Powell, Report on Observations of Luminous Meteors, 1854–55; —Report of Committee appointed to inquire into the best means of ascertaining those properties of Metals and effects of various modes of treating them which are of importance to the durability and efficiency of Artillery;—Rev. Prof. Henslow, Report on Typical Objects in Natural History;—A. Follett Osler, Account of the Self-Registering Anemometer and Rain-Gauge at the Liverpool Observatory;—Provisional Reports.

Together with the Transactions of the Sections, the Duke of Argyll's Address, and Recommendations of the Association and its Committees.

## PROCEEDINGS OF THE TWENTY-SIXTH MEETING, at Cheltenham, 1856, *Published at* 18*s.*

CONTENTS:—Report from the Committee appointed to investigate and report upon the effects produced upon the Channels of the Mersey by the alterations which within the last fifty years have been made in its Banks;—J. Thomson, Interim Report on progress in Researches on the Measurement of Water by Weir Boards;—Dredging Report, Frith of Clyde, 1856;—Rev. B. Powell, Report on Observations of Luminous Meteors, 1855–1856;—Prof. Bunsen and Dr. H. E. Roscoe, Photochemical Researches;—Rev. James Booth, on the Trigo-

nometry of the Parabola, and the Geometrical Origin of Logarithms;—R. MacAndrew, Report on the Marine Testaceous Mollusca of the North-east Atlantic and Neighbouring Seas, and the physical conditions affecting their development;—P. P. Carpenter, Report on the present state of our knowledge with regard to the Mollusca of the West Coast of North America;—T. C. Eyton, Abstract of First Report on the Oyster Beds and Oysters of the British Shores;—Prof. Phillips, Report on Cleavage and Foliation in Rocks, and on the Theoretical Explanations of these Phenomena: Part I.;—Dr. T. Wright on the Stratigraphical Distribution of the Oolitic Echinodermata;—W. Fairbairn, on the Tensile Strength of Wrought Iron at various Temperatures;—C. Atherton, on Mercantile Steam Transport Economy;—J. S. Bowerbank, on the Vital Powers of the Spongiadæ;—Report of a Committee upon the Experiments conducted at Stormontfield, near Perth, for the artificial propagation of Salmon;—Provisional Report on the Measurement of Ships for Tonnage;—On Typical Forms of Minerals, Plants and Animals for Museums;—J. Thomson, Interim Report on Progress in Researches on the Measurement of Water by Weir Boards;—R. Mallet, on Observations with the Seismometer;—A. Cayley, on the Progress of Theoretical Dynamics;—Report of a Committee appointed to consider the formation of a Catalogue of Philosophical Memoirs.

Together with the Transactions of the Sections, Dr. Daubeny's Address, and Recommendations of the Association and its Committees.

## PROCEEDINGS OF THE TWENTY-SEVENTH MEETING, at Dublin, 1857, *Published at* 15*s*.

CONTENTS:—A. Cayley, Report on the Recent Progress of Theoretical Dynamics;—Sixteenth and final Report of Committee on Experiments on the Growth and Vitality of Seeds;—James Oldham, C.E., continuation of Report on Steam Navigation at Hull;—Report of a Committee on the Defects of the present methods of Measuring and Registering the Tonnage of Shipping, as also of Marine Engine-Power, and to frame more perfect rules, in order that a correct and uniform principle may be adopted to estimate the Actual Carrying Capabilities and Working-Power of Steam Ships;—Robert Were Fox, Report on the Temperature of some Deep Mines in Cornwall;—Dr. G. Plarr, De quelques Transformations de la Somme $\Sigma_0^t \frac{-\alpha\ a^{\underline{t+1}}\beta^{\underline{t+1}}\delta^{\underline{t+1}}}{1^{\underline{t+1}}\gamma^{\underline{t+1}}\epsilon^{\underline{t+1}}}$, $\alpha$ étant entier négatif, et de quelques cas dans lesquels cette somme est exprimable par une combinaison de factorielles, la notation $a^{\underline{t+1}}$ désignant le produit des $t$ facteurs $a\ (a+1)\ (a+2)$ &c....$(a+t-1)$;—G. Dickie, M.D., Report on the Marine Zoology of Strangford Lough, County Down, and corresponding part of the Irish Channel;—Charles Atherton, Suggestions for Statistical Inquiry into the extent to which Mercantile Steam Transport Economy is affected by the Constructive Type of Shipping, as respects the Proportions of Length, Breadth, and Depth;—J. S. Bowerbank, Further Report on the Vitality of the Spongiadæ;—John P. Hodges, M.D., on Flax;—Major-General Sabine, Report of the Committee on the Magnetic Survey of Great Britain;—Rev. Baden Powell, Report on Observations of Luminous Meteors, 1856–57;—C. Vignoles, C.E., on the Adaptation of Suspension Bridges to sustain the passage of Railway Trains;—Professor W. A. Miller, M.D., on Electro-Chemistry;—John Simpson, R.N., Results of Thermometrical Observations made at the 'Plover's' Wintering-place, Point Barrow, latitude 71° 21′ N., long. 156° 17′ W., in 1852–54;—Charles James Hargreave, LL.D., on the Algebraic Couple; and on the Equivalents of Indeterminate Expressions;—Thomas Grubb, Report on the Improvement of Telescope and Equatorial Mountings;—Professor James Buckman, Report on the Experimental Plots in the Botanical Garden of the Royal Agricultural College at Cirencester;—William Fairbairn on the Resistance of Tubes to Collapse;—George C. Hyndman, Report of the Proceedings of the Belfast Dredging Committee;—Peter W. Barlow, on the Mechanical Effect of combining Girders and Suspension Chains, and a Comparison of the Weight of Metal in Ordinary and Suspension Girders, to produce equal deflections with a given load;—J. Park Harrison, M.A., Evidences of Lunar Influence on Temperature;—Report on the Animal and Vegetable Products imported into Liverpool from the year 1851 to 1855 (inclusive);—Andrew Henderson, Report on the Statistics of Life-boats and Fishing-boats on the Coasts of the United Kingdom.

Together with the Transactions of the Sections, Rev. H. Lloyd's Address, and Recommendations of the Association and its Committees.

## PROCEEDINGS OF THE TWENTY-EIGHTH MEETING, at Leeds, September 1858, *Published at* 20*s*.

CONTENTS:—R. Mallet, Fourth Report upon the Facts and Theory of Earthquake Phenomena;—Rev. Prof. Powell, Report on Observations of Luminous Meteors, 1857–58;—R. H. Meade, on some Points in the Anatomy of the Araneidea or true Spiders, especially on the

internal structure of their Spinning Organs;—W. Fairbairn, Report of the Committee on the Patent Laws;—S. Eddy, on the Lead Mining Districts of Yorkshire;—W. Fairbairn, on the Collapse of Glass Globes and Cylinders;—Dr. E. Perceval Wright and Prof. J. Reay Greene, Report on the Marine Fauna of the South and West Coasts of Ireland;—Prof. J. Thomson, on Experiments on the Measurement of Water by Triangular Notches in Weir Boards;—Major-General Sabine, Report of the Committee on the Magnetic Survey of Great Britain;—Michael Connal and William Keddie, Report on Animal, Vegetable, and Mineral Substances imported from Foreign Countries into the Clyde (including the Ports of Glasgow, Greenock, and Port Glasgow) in the years 1853, 1854, 1855, 1856, and 1857;—Report of the Committee on Shipping Statistics;—Rev. H. Lloyd, D.D., Notice of the Instruments employed in the Magnetic Survey of Ireland, with some of the Results;—Prof. J. R. Kinahan, Report of Dublin Dredging Committee, appointed 1857–58;—Prof. J. R. Kinahan, Report on Crustacea of Dublin District;—Andrew Henderson, on River Steamers, their Form, Construction, and Fittings, with reference to the necessity for improving the present means of Shallow-Water Navigation on the Rivers of British India;—George C. Hyndman, Report of the Belfast Dredging Committee;—Appendix to Mr. Vignoles's paper "On the Adaptation of Suspension Bridges to sustain the passage of Railway Trains;"—Report of the Joint Committee of the Royal Society and the British Association, for procuring a continuance of the Magnetic and Meteorological Observatories;—R. Beckley, Description of a Self-recording Anemometer.

Together with the Transactions of the Sections, Prof. Owen's Address, and Recommendations of the Association and its Committees.

## PROCEEDINGS OF THE TWENTY-NINTH MEETING, at Aberdeen, September 1859, *Published at* 15*s*.

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## PROCEEDINGS OF THE THIRTIETH MEETING, at Oxford, June and July 1860, *Published at* 15*s*.

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## PROCEEDINGS OF THE THIRTY-FIRST MEETING, at Manchester, September 1861, *Published at* £1.

CONTENTS:—James Glaisher, Report on Observations of Luminous Meteors;—Dr. E. Smith, Report on the Action of Prison Diet and Discipline on the Bodily Functions of Prisoners, Part I.;—Charles Atherton, on Freight as affected by Differences in the Dynamic Properties of Steamships;—Warren De la Rue, Report on the Progress of Celestial Photography since the Aberdeen Meeting;—B. Stewart, on the Theory of Exchanges, and its recent extension;—Drs. E. Schunck, R. Angus Smith, and H. E. Roscoe, on the Recent Progress and Present Condition of Manufacturing Chemistry in the South Lancashire District;—Dr. J. Hunt, on Ethno-Climatology; or, the Acclimatization of Man;—Prof. J. Thomson, on Experiments on the Gauging of Water by Triangular Notches;—Dr. A. Voelcker, Report on Field Experiments and Laboratory Researches on the Constituents of Manures essential to cultivated Crops;—Prof. H. Hennessy, Provisional Report on the Present State of our Knowledge respecting the Transmission of Sound-signals during Fogs at Sea;—Dr. P. L. Sclater and F. von Hochstetter, Report on the Present State of our Knowledge of the Birds of the Genus *Apteryx* living in New Zealand;—J. G. Jeffreys, Report of the Results of Deep-sea Dredging in Zetland, with a Notice of several Species of Mollusca new to Science or to the British Isles;—Prof. J. Phillips, Contributions to a Report on the Physical Aspect of the Moon;—W. R. Birt, Contribution to a Report on the Physical Aspect of the Moon;—Dr. Collingwood and Mr. Byerley, Preliminary Report of the Dredging Committee of the Mersey and Dee;—Third Report of the Committee on Steamship Performance;—J. G. Jeffreys, Preliminary Report on the Best Mode of preventing the Ravages of *Teredo* and other Animals in our Ships and Harbours;—R. Mallet, Report on the Experiments made at Holyhead to ascertain the Transit-Velocity of Waves, analogous to Earthquake Waves, through the local Rock Formations;—T. Dobson, on the Explosions in British Coal-Mines during the year 1859;—J. Oldham, Continuation of Report on Steam Navigation at Hull;—Professor G. Dickie, Brief Summary of a Report on the Flora of the North of Ireland;—Professor Owen, on the Psychical and Physical Characters of the Mincopies, or Natives of the Andaman Islands, and on the Relations thereby indicated to other Races of Mankind;—Colonel Sykes, Report of the Balloon Committee;—Major-General Sabine, Report on the Repetition of the Magnetic Survey of England;—Interim Report of the Committee for Dredging on the North and East Coasts of Scotland;—W. Fairbairn, on the Resistance of Iron Plates to Statical Pressure and the Force of Impact by Projectiles at High Velocities;—W. Fairbairn, Continuation of Report to determine the effect of Vibratory Action and long-continued Changes of Load upon Wrought-Iron Girders;—Report of the Committee on the Law of Patents;—Prof. H. J. S. Smith, Report on the Theory of Numbers, Part III.

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## PROCEEDINGS OF THE THIRTY-SECOND MEETING, at Cambridge, October 1862, *Published at* £1.

CONTENTS:—James Glaisher, Report on Observations of Luminous Meteors, 1861–62;—G. B. Airy, on the Strains in the Interior of Beams;—Archibald Smith and F. J. Evans, Report on the three Reports of the Liverpool Compass Committee;—Report on Tidal Observations on the Humber;—T. Aston, on Rifled Guns and Projectiles adapted for Attacking

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Account of Nine Balloon Ascents made in 1863 and 1864;—J. G. Jeffreys, Further Report on Shetland Dredgings;—Report of the Committee on the Distribution of the Organic Remains of the North Staffordshire Coal-field;—Report of the Committee on Standards of Electrical Resistance;—G. J. Symons, on the Fall of Rain in the British Isles in 1862 and 1863;—W. Fairbairn, Preliminary Investigation of the Mechanical Properties of the proposed Atlantic Cable.

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1854. †*Archer, Francis.*
1855. *Archer, Professor T. C., F.R.S.E., Director of the Industrial Museum. 9 Argyll-place, Edinburgh.
1851. †Argyll, The Duke of, K.T., LL.D., F.R.S. L. & E., F.G.S. Argyll Lodge, Kensington, London; and Inverary, Argyllshire.
1865. †Armitage, J. W., M.D. 9 Huntriss-row, Scarborough.
1861. §Armitage, William. 7 Meal-street, Mosley-street, Manchester.
Armstrong, Thomas. Higher Broughton, Manchester.
1857. *Armstrong, Sir William George, C.B., LL.D., F.R.S. 8 Great George-street, London, S.W.; and Elswick Works, Newcastle-on-Tyne.
1856. †Armstrong, William Jones, M.A. Mount Irwin, Tynna, Co. Armagh.
Arnott, George A. Walker, LL.D., F.R.S.E., F.L.S., Professor of Botany in the University of Glasgow. Arlary, Kinross-shire.
Arnott, Neil, M.D., F.R.S., F.G.S. 2 Cumberland-terrace, Regent's Park, London.
1864. §Arrowsmith, John. Hereford-square, Old Bompton, London, S.W.
1853. *Arthur, Rev. William, M.A. Glendun, East Acton, London, W.
Ashhurst, Thomas Henry, D.C.L. All Souls' College, Oxford.
1842. *Ashton, Thomas, M.D. 81 Mosley-street, Manchester.
Ashton, Thomas. Ford Bank, Didsbury, Manchester.
1866. §Ashwell, Henry. Mount-street, New Basford, Nottingham.
*Ashworth, Edmund. Egerton Hall, Turton, near Bolton.
Ashworth, Henry. Turton, near Bolton.
1845. †Ashworth, Rev. J. A. Dudcote, Abingdon.
1861. §Aspland, Alfred. Dukinfield, Ashton-under-Lyne, Lanrey, Windermere.
Aspland, Algernon Sydney. Saury, Windermere.
Aspland, Rev. R. Brook, M.A. 1 Frampton Villas, South Hackney, London.
1861. §Asquith, J. R. Infirmary-street, Leeds.
1861. †Aston, Thomas. 4 Elm-court, Temple, London, E.C.
1858. †Atherton, Charles. Sandover, Isle of Wight.
1866. §Atherton, J. H. Long-row, Nottingham.
1865. §Atkin, Alfred. Griffin's-hill, Birmingham.
1861. †Atkin, Eli. Newton Heath, Manchester.
1865. *Atkinson, Edmund, F.C.S. Royal Military College, Sandhurst, Farnborough.
1863. *Atkinson, G. Clayton. Wyland Hall, West Denton, Newcastle-on-Tyne.
1861. †*Atkinson, James.*
1845. †*Atkinson John.*

Year of Election.

1858. *Atkinson, John Hastings. 14 East Parade, Leeds.
1842. *Atkinson, Joseph B. Stratford House, Carlisle-terrace, Kensington, W.
1861. †Atkinson, Rev. J. A. Longsight Rectory, near Manchester.
1858. **Atkinson, J. R. W.*
Atkinson, William. Ashton Hayes, near Chester.
1863. §Attfield, Dr. J. 17 Bloomsbury-square, London, W.C.
**Auldjo, John, F.G.S.*
1859. †*Austin, Alfred.*
1860. *Austin-Gourlay, Rev. William E. C., M.A. Stoke Abbott Rectory, Beaminster, Dorset.
1865. *Avery, Thomas. Church-road, Edgbaston, Birmingham.
1865. *Avery, William Henry. Digbeth, Birmingham.
1853. *Ayrton, W. S., F.S.A. The Mount, York.

Babbage, B. H. 1 Dorset-street, Manchester-square, London, W.
*Babbage, Charles, M.A., F.R.S. L. & E., Hon. M.R.I.A., F.R.A.S. 1 Dorset-street, Manchester-square, London, W.
*Babington, Charles Cardale, M.A., F.R.S., F.L.S., F.G.S., Professor of Botany in the University of Cambridge. (*Local Treasurer.*) St. John's College, Cambridge.
Bache, Rev. Samuel. 44 Frederick-street, Edgbaston, near Birmingham.
1845. †Back, Rear-Admiral Sir George, D.C.L., F.R.S., F.R.G.S. 109 Gloucester-place, Portman-square, London, W.
Backhouse, Edmund. Darlington.
1863. †Backhouse, J. W. Sunderland.
Backhouse, Thomas James. Sunderland.
1851. †Bacon, George. Tavern-street, Ipswich.
**Baddeley, Captain Frederick H., R.E.*
Bagot, Thomas N. Ballymoe, Co. Galway.
1864. *Bailey, C. D. 7 Camden-crescent, Bath.
Bailey, Samuel. Sheffield.
1865. †Bailey, Samuel. The Peck, Walsall.
1855. †Bailey, William. Horseley Fields Chemical Works, Wolverhampton.
1866. §Baillon, Andrew. St. Mary's Gate, Nottingham.
1866. §Baillon, L. St. Mary's Gate, Nottingham.
1857. †Baily, William Hellier, F.L.S., F.G.S., Acting Palæontologist to the Geological Survey of Ireland. 51 Stephen's Green, Dublin.
*Bain, Richard. Gwennap, near Truro.
1865. §Bain, Rev. W. J. Wellingborough.
Bainbridge, Joseph. (Messrs. Morris and Prevost, Gresham House, London.)
*Bainbridge, Robert Walton. Middleton House, near Barnard Castle, Durham.
*Baines, Edward. Headingley Lodge, Leeds.
1858. †Baines, Frederick. Burley, near Leeds.
1858. *Baines, Samuel. Victoria Mills, Brighouse, Yorkshire.
1865. §Baines, T. 14 Union-street, King's Lynn, Norfolk.
1858. †Baines, T. Blackburn. 'Mercury' Office, Leeds.
1851. †Baird, A. W., M.D. Lower Brook-street, Ipswich.
1866. §Baker, Francis B. Arboretum Street, Nottingham.
1846. †*Baker, Rev. Franklin.*
1858. *Baker, Henry Granville. Bellevue, Horsforth, near Leeds.
1865. †Baker, James P. Wolverhampton.
1861. *Baker, John. Catley-hill, Cheadle, Cheshire.
1861. *Baker, John. (R. Brooks & Co., St. Peter's Chambers, Cornhill, London.)
1865. §Baker, Robert L. Victoria-villa, Moseley-road, Birmingham.

Year of Election.

1847. ‡Baker, Thomas B. Lloyd. Hardwick-court, Gloucester.
1849. *Baker, William. 63 Gloucester-place, Hyde Park, London, W.
1863. §Baker, William. 6 Taptonville, Sheffield.
1845. ‡Bakewell, Frederick. 6 Haverstock-terrace, Hampstead, London, N.W.
1860. §Balding, James, M.R.C.S. Barkway, Royston, Herts.
1851. *Baldwin, The Hon. Robert, H.M. Attorney-General. Spadina, Co. York, Upper Canada.
*Balfour, John Hutton, M.D., M.A., F.R.S. L. & E., F.L.S., Professor of Medicine and Botany in the University of Edinburgh. 27 Inverleith-row, Edinburgh.
*Ball, John, M.R.I.A., F.L.S. Oxford and Cambridge Club, Pall Mall, London.
1866. §Ball, Robert. 43 Wellington Place, Dublin.
1863. §Ball, Thomas. Bramcote, Nottingham.
*Ball, William. Bruce-grove, near London, and Rydall, Ambleside, Westmoreland.
1852. ‡Bangor, Viscount. Castleward, Co. Down, Ireland.
1850. ‡Banks, Richard William. Kington, Herefordshire.
1846. ‡Banks, Rev. S. H., LL.D. Dullingham, Newmarket.
1842. *Bannerman, Alexander.*
1861. ‡Bannerman, James Alexander. Limefield House, Higher Broughton, near Manchester.
1853. ‡*Bannister, Anthony.*
1866. §Barber, John. Long-row, Nottingham.
1861. *Barbour, George. Bolesworth Castle, Tattenhall, Chester.
1859. ‡Barbour, George F. Bouskeid, Edinburgh.
*Barbour, Robert. Bolesworth Castle, Chester.
1855. ‡Barclay, Andrew. Kilmarnock, Scotland.
Barclay, Charles, F.S.A., M.R.A.S. Bury-hill, Dorking.
Barclay, James. Catrine, Ayrshire.
1852. *Barclay, J. Gurney. Walthamstow, Essex.
1860. *Barclay, Robert. Leyton, Essex.
1863. ‡Barford, J. Gale. Wellington College, Berks.
1860. *Barker, Rev. Arthur Alcock, B.D. East Bridgeford Rectory, Notts.
1857. ‡Barker, John, M.D., Curator of the Royal College of Surgeons of Ireland. Dublin.
1865. ‡Barker, Stephen. 30 Frederick-street, Edgbaston, Birmingham.
1846. ‡Barlow, Rev. John, M.A., F.R.S., F.L.S., F.G.S. 5 Berkeley-street, London, W.
Barlow, Lieut.-Col. Maurice (14th Regt. of Foot). 5 Great George-street, Dublin.
Barlow, Peter. 5 Great George-street, Dublin.
1857. ‡Barlow, Peter William, F.R.S., F.G.S. 26 Great George-street, Westminster, London.
1861. *Barnard, Major R. Cary. Cambridge House, Bays-hill, Cheltenham.
1864. *Barneby, John H. Brockhampton Park, Worcester.
Barnes, Rev. Joseph Watkins, M.A., F.C.P.S. Kendal, Westmoreland.
*Barnes, Thomas, M.D., F.R.S.E. Carlisle.
*Barnes, Thomas Addison.*
*Barnett, Richard, M.R.C.S. 16 The Crescent, Oxford.
1859. ‡Barr, Lieut.-Colonel, Bombay Army. (Messrs. Forbes, Forbes & Co., 9 King William-street, London.)
1861. *Barr, W. R. Norris Bank, Heaton Norris, Stockport.
1860. ‡Barrett, T. B. High-street, Welshpool, Montgomery.
1852. §Barrington, Edward. Fassaroe Bray, Co. Wicklow.
1852. ‡Barrington, Richard S. Trafalgar-terrace, Monkstown, Co. Dublin.
1866. §Barron, William. Elvaston Nurseries, Borrowash, Derby.
1863. Barrow, Capt. C. J. Southwell.

Year of Election.

1858. ‡*Barry, Rev. A.*
1862. *Barry, Charles. Lapswood, Sydenham-hill, Kent.
Barstow, Thomas. Garrow-hill, near York.
1858. *Bartholomew, Charles. Broxholme, Doncaster.
1855. ‡Bartholomew, Hugh. New Gas-works, Glasgow.
1858. *Bartholomew, William Hamond. 5 Grove-terrace, Leeds.
1851. ‡Bartlet, A. H. Lower Brook-street, Ipswich.
1857. ‡Barton, Folloit W. Clonelly, Co. Fermanagh.
1852. ‡Barton, James. Farndreg, Dundalk.
*Barton, John. Bank of Ireland, Dublin.
1864. §Bartrum, John S. 41 Gay-street, Bath.
1858. *Barwick, John Marshall. Albion-street, Leeds.
*Bashforth, Rev. Francis, B.D. Minting, near Horncastle, Lincolnshire.
1861. ‡Bass, John H., F.G.S. 287 Camden-road, London, N.
1866. *Bassett, Henry. 19 Alfred-place, Bedford-square, London.
1866. §Bassett, Richard. Pelham-street, Nottingham.
1850. ‡Bastard, Thomas H. Charleton, Blandford.
1848. ‡Bate, C. Spence, F.R.S., F.L.S. 8 Mulgrave-place, Plymouth.
Bateman, James, M.A., F.R.S., F.L.S., F.H.S. Knypersley Hall, near Congleton, Staffordshire.
1842. *Bateman, John Frederic, C.E., F.R.S., F.G.S. 16 Great George-street, Westminster, London.
*Bateman, Joseph, LL.D., F.R.A.S. Walthamstow, London, N.E.
1864. §Bates, Henry Walter, Assist.-Sec. R.G.S. 15 Whitehall-place, London, S.W.
Bateson, John Glynn. Liverpool.
1852. ‡Bateson, Sir Robert, Bart. Belvoir Park, Belfast.
1866. §Bathoe, Charles. 28 York-place, Portman-square, London, W.
1863. *Bathurst, Rev. W. H. Lydney Park, Gloucestershire.
1863. §Bauerman, H. 22 Acre-lane, Brixton, London.
1861. ‡Baxendell, Joseph, F.R.A.S. 108 Stock-street, Manchester.
1858. ‡*Baxter, Robert.*
*Bayldon, John. Horbury, near Wakefield.
1851. *Bayley, George. 2 Cowper's-court, Cornhill, London, E.C.
1866. §Bayley, Thomas. Lenton, Nottingham.
1854. ‡Baylis, C. O., M.D. 51 Hamilton-square, Birkenhead.
1855. ‡*Bayly, Capt., R.E.*
Bayly, John. 1 Brunswick-terrace, Plymouth.
1842. Bazley, Thomas Sebastian, B.A. Agden Hall, Lymm, Warrington.
*Beal, Captain. Toronto, Upper Canada.*
1860. *Beale, Lionel S., M.B., F.R.S., Professor of Physiology and of General and Morbid Anatomy in King's College, London. 61 Grosvenor-street, London, W.
*Beamish, Francis B.*
*Beamish, Richard, F.R.S. (*Local Treasurer.*) Brightstone, Newport, Isle of Wight.
1861. §Bean, William. Alfreton, Derbyshire.
1866. *Beardmore, Nathanial. 30 Great George-street, Westminster, London.
*Beatson, William. Rotherham.
1857. ‡*Beattie, Joseph.*
1855. **Beaufort, William Morris, F.R.G.S. India.*
1861. *Beaumont, Rev. Thomas George. Chelmondiston Rectory, Ipswich.
1859. *Beck, Joseph, F.R.A.S. 31 Cornhill, London.
1851. §*Becker, Ernest, Ph.D. Darmstadt.*
1864. §Becker, Miss L. E. 10 Grove-street, Ardwick, Manchester.
1865. §Beckett, Henry, F.G.S. Pecnover, near Wolverhampton.
1858. *Beckett, William. Kirkstall Grange, Leeds.
1860. ‡Beckles, Samuel H., F.R.S., F.G.S. Enden-villas, Schiest-road, South Norwood.

Year of Election.

1866. §Beddard, James. Derby-road, Nottingham.
1846. ‡Beddome, J., M.D. Romsey, Hants.
1854. ‡*Bedford, James, Ph.D.*
1858. ‡*Bedford, James.*
1850. ‡Begbie, James, M.D. 21 Alva-street, Edinburgh.
1846. ‡Beke, Charles T., Ph.D., F.S.A., F.R.G.S. Bekesbourne House, near Canterbury, Kent.
1865. *Belavenetz, I., Captain of the Russian Imperial Navy, F.R.I.G.S., M.S.C.M.A., Superintendent of the Compass Observatory, Cronstadt. (Care of Messrs. Baring Brothers, Bishopsgate-street, London.)
1847. *Belcher, Vice-Admiral Sir Edward, Knt. C.B., F.R.A.S., F.R.G.S. 22A Connaught-square, Edgeware-road, London, W.
1847. ‡Belcher, William. Abingdon.
1850. ‡Bell, Charles, M.D. 3 St. Colme-street, Edinburgh.
Bell, Frederick John. Woodlands, near Maldon, Essex.
1859. ‡Bell, George. Windsor-buildings, Dumbarton.
1860. ‡Bell, Rev. George Charles, M.A. The College, Dulwich, Surrey, S.
1855. ‡Bell, Capt. Henry. Chalfont Lodge, Cheltenham.
1862. *Bell, Isaac Lowthian. The Hall, Washington, Co. Durham.
1853. ‡Bell, John Pearson, M.D. Waverley House, Hull.
*Bell, Matthew P. 245 St. Vincent-street, Glasgow.
1859. ‡Bell, Robert, jun. 3 Airlie-place, Dundee.
1864. ‡Bell, R. Queen's College, Kingston, Canada.
1855. ‡*Bell, the late Sheriff. Glasgow.*
Bell, Thomas, F.R.S., F.L.S., F.G.S., Professor of Zoology, King's College, London. The Wakes, Selborne, near Alton, Hants.
1863. *Bell, Thomas. Usworth House, Gateshead, Durham.
1842. Bellhouse, Edward Taylor. Eagle Foundry, Manchester.
1854. ‡Bellhouse, William Dawson. 1 Park-street, Leeds.
Bellingham, Sir Alan. Castle Bellingham, Ireland.
1866. *Belper, The Right Hon. Lord, M.A., F.R.S., F.G.S. 88 Eaton-square, London, S.W.; and Kingston Hall, Nottingham.
1864. **Bendyshe, T.*
1848. ‡Benham, E. 18 Essex-street, Strand, London.
1850. ‡Bennett, John Hughes, M.D., F.R.S.E., Professor of Institutes of Medicine in the University of Edinburgh. 1 Glenfinlas-street, Edinburgh.
1852. *Bennoch, Francis. The Knoll, Blackheath, Kent.
1857. ‡Benson, Charles. 11 Fitzwilliam-square West, Dublin.
Benson, Robert, jun. Fairfield, Manchester.
1848. ‡Benson, Starling, F.G.S. Gloucester-place, Swansea.
1863. ‡Benson, William. Fourstones Court, Newcastle-on-Tyne.
1848. ‡Bentham, George, F.R.S., Pres. L.S. 26 Wilton-place, Knightsbridge, London.
1842. Bentley, John. 9 Portland-place, London.
1845. ‡Bentley, J. Flowers. Stamford, Lincolnshire,
1863. §Bentley, Robert, F.L.S., Professor of Botany in King's College. 55 Clifton-road, St. John's-wood, London, N.W.
1865. §Berger, C. H., F.C.S. Lower Clapton, London, N.E.
1863. ‡Berkley, C. Marley Hill, Gateshead, Durham.
1848. ‡Berrington, Arthur V. D. Woodlands Castle, near Swansea.
*Berryman, William Richard. 6 Tamar-terrace, Stoke, Devonport.
1862. ‡Besant, William Henry, M.A. St. John's College, Cambridge.
1865. §Bessemer, Henry. Denmark-hill, Camberwell, London, S.
1858. ‡Best, William. Leydon-terrace, Leeds.
1865. §Bevan, Hugh J. C. The Temple, London, E.C.
1859. ‡Beveridge, Robert, M.B. 20 Union-street, Aberdeen.

Year of Election.

1863. ‡Bewick, Thomas John. Allenheads, Carlisle.
*Bickerdike, Rev. John, M.A. St. Mary's Parsonage, Leeds.
Bickersteth, Robert. Rodney-street, Liverpool.
1863. ‡Bigger, Benjamin. Gateshead, Durham.
1864. ‡Biggs, Robert. 17 Charles-street, Bath.
1855. ‡Billings, Robert William. 4 St. Mary's-road, Canonbury, London, N.
Bilton, Rev. William, M.A., F.G.S. United University Club, Suffolk-street, London, S.W.; and Chislehurst, Kent.
1842. Binney, Edward William, F.R.S., F.G.S. 40 Cross-street, Manchester.
1842. *Binyon, Thomas. Henwick Grove, Worcester.
Birchall, Edwin. College-house, Bradford.
Birchall, Henry. Scarsdale-villas, Kensington.
1854. ‡Bird, William Smith. Dingle Priory, near Liverpool.
1865. ‡Birkenhead, Edward Hasketh, D.Sc., F.G.S., Royal Infirmary School of Medicine, Liverpool.
*Birkenshaw, John Cass.*
1862. §Birkin, Richard. Apsley Hall, Nottingham.
1866. *Birkin, Richard, jun. The Park, Nottingham.
**Birks, Rev. Thomas Rawson.*
1842. *Birley, Richard. Seedley, Pendleton, Manchester.
1861. ‡Birley, Thomas Thornely. Highfield, Heaton Mersey, Manchester.
1841. *Birt, William Radcliff, F.R.A.S. Cynthia-villa, Clarendon-road, Walthamstow.
1854. ‡*Bishop, Rev. Francis.*
1866. §Bishop, Thomas. Bramcote, Nottingham.
1863. ‡Black, William. South Shields.
*Blackburn, Bewicke.*
Blackburne, Right Hon. Francis. 34 Merrion-square South, Dublin.
Blackburne, Rev. John, M.A. Yarmouth, Isle of Wight.
Blackburne, Rev. John, jun., M.A. Rectory, Horton, near Chippenham.
1859. ‡Blackie, John Stewart, Professor of Greek. Edinburgh.
1855. *Blackie, W. G., Ph.D., F.R.G.S. 10 Kew-terrace, Glasgow.
*Blackwall, John, F.L.S. Hendre House, near Llanrwst, Denbighshire.
1863. ‡Bladen, Charles. Jarrow Iron Company, Newcastle-on-Tyne.
1859. ‡Blaikie, Sir Thomas. Kingseat, Aberdeen.
1863. §Blake, C. Carter, F.G.S. Anthropological Society, 4 St. Martin's-place, Trafalgar-square, London, W.C.
1849. *Blake, Henry Wollaston, M.A., F.R.S. 8 Devonshire-place, Portland-place, London, W.
1846. *Blake, William. South Petherton, Ilminster.
1865. *Blakeley, Captain. Blakeley Ordnance Company, Bear-lane, Southwark, London.
1860. ‡Blakeley, Capt. A. T. 34 Montpellier-square, Knightsbridge, London.
1845. ‡Blakesley, Rev. J. W., B.D. Ware Vicarage, Hertfordshire.
1861. §Blakiston, Matthew. Mobberley, Knutsford.
*Blakiston, Peyton, M.D., F.R.S. St. Leonard's-on-Sea.
*Bland, Rev. Miles, D.D., F.R.S., F.S.A., F.R.A.S. 5 Royal-crescent, Ramsgate.
Blanshard, William. Redcar.
Blore, Edward, F.S.A. 4 Manchester-square, London, W.
1853. ‡Blundell, Henry J. P. Brunswick House, Beverley-road, Hull.
1859. ‡Blunt, Sir Charles, Bart. Heathfield Park, Sussex.
Blunt, Henry. Shrewsbury.
1859. ‡Blunt, Capt. Richard. Bretlands, Chertsey, Surrey.
Blyth, B. Hall. 135 George-street, Edinburgh.

Year of Election.

1850. ‡Blyth, John, M.D., Professor of Chemistry in Queen's College, Cork.
1858. *Blythe, William. Holland Bank, Church, near Accrington.
Boase, C. W. Dundee.
1845. ‡Bodmer, Rodolphe. Newport, Monmouthshire.
1864. ‡Bogg, J. Louth, Lincolnshire.
1866. §Bogg, Thomas Wemyss. Louth, Lincolnshire.
1859. *Bohn, Henry G., F.R.G.S. York-street, Covent Garden, London.
*Boileau, Sir John Peter, Bart., F.R.S. 20 Upper Brook-street, London; and Ketteringham Hall, Norfolk.
1859. ‡Bolster, Rev. Prebendary John A. Cork.
Bolton, R. L. Gambier-terrace, Liverpool.
1849. ‡Bolton, Thomas. Hyde House, near Stourbridge.
1866. §Bond, Banks. Low Pavement, Nottingham.
1863. ‡Bond, Francis T., M.D. Hartley Institution, Southampton.
Bond, Henry John Hayes, M.D. Cambridge.
Bonomi, Ignatius. 36 Blandford-square, London, N.W.
Bonomi, Joseph. Soane's Museum, 15 Lincoln's-Inn-fields, London.
1866. §Booker, W. H. Cromwell-terrace, Nottingham.
1861. §Booth, James. Castlemere, Rochdale.
1835. ‡Booth, Rev. James, LL.D., F.R.S., F.R.A.S. The Vicarage, Stone, near Aylesbury.
1861. *Booth, John. Monton, near Manchester.
1861. *Booth, Councillor William. Dawson-street, Manchester.
1861. *Borchardt, Dr. Louis. Bloomsbury, Oxford-road, Manchester.
1849. ‡Boreham, William W., F.R.A.S. Haverhill, Suffolk.
1863. ‡Borries, Theodore. Lovaine-crescent, Newcastle-on-Tyne.
*Bossey, Francis, M.D. Oxford-terrace, Red Hill, Surrey.
Bosworth, Rev. Joseph, LL.D., F.R.S., F.S.A., M.R.I.A., Professor of Anglo-Saxon in the University of Oxford. Oxford.
1859. ‡Bothwell, George B. 9 Bon Accord-square, Aberdeen.
1858. ‡Botterill, John. Burley, near Leeds.
Bottomley, William. Forbreda, Belfast.
1850. ‡Bouch, Thomas, C.E. 1 South Hanover-street, Edinburgh.
Bourne, Lieut.-Col. J. D. Heathfield, Liverpool.
1866. §Bourne, Stephen. Hudstone-drive, Harrow.
1858. ‡Bousfield, Charles. Roundhay, near Leeds.
1846. *Bowerbank, James Scott, LL.D., F.R.S., F.R.A.S. 2 East Ascent, St. Leonard's.
1856. *Bowlby, Miss F. E. 27 Lansdown-crescent, Cheltenham.
1866. *Bowman, E. Victoria Park, Manchester.
1863. ‡Bowman, R. Benson. Newcastle-on-Tyne.
Bowman, William, F.R.S. 5 Clifford-street, London, W.
‡Bowring, Sir John, LL.D., F.R.S. Athenæum Club, Pall Mall, London; and Claremont, Exeter.
1863. §Bowron, James. South Stockton-on-Tees.
1863. §Boyd, Edward Fenwick. Moor House, near Durham.
Boyle, Alexander, M.R.I.A. 35 College Green, Dublin.
1865. ‡Boyle, Rev. G. D. Soho House, Handsworth, Birmingham.
Brabant, R. H., M.D. Bath.
Bracebridge, Charles Holt, F.R.G.S. The Hall, Atherstone, Warwickshire.
1849. ‡Bracey, Charles. Birmingham.
1864. §Bradbury, Thomas. Longroyde, Brighouse.
*Bradshaw, Rev. John.*
1861. *Bradshaw, William. Mosley-street, Manchester.
1842. *Brady, Antonio. Maryland Point, Essex.
1857. *Brady, Cheyne, M.R.I.A. Four Courts, Co. Dublin.
Brady, Daniel F., M.D. 5 Gardiner's Row, Dublin.

Year of Election.

1868. ‡Brady, George S. 22 Fawcett-street, Sunderland.
1862. §Brady, Henry Bowman, F.L.S., F.G.S. 40 Mosley-street, Newcastle-on-Tyne.
1858. ‡Brae, Andrew Edmund. 29 Park-square, Leeds.
1864. §Braham, P. 35A Great George-street, Westminster, London.
1864. §Braikenridge, Rev. George Weare, M.A., F.L.S. Clevedon, Somerset.
*Brakenridge, John. Wakefield.
1865. §Bramwell, F. J. 35A Great George-street, Westminster, London.
Brancker, Rev. Thomas, M.A. Limington, Somerset.
1850. ‡Brand, William, F.R.S.E. 5 Northumberland-street, Edinburgh.
1861. *Brandreth, Henry. Worthing.
Brandreth, John Moss. Preston, Lancashire.
1852. ‡Brazier, James S. Professor of Chemistry in Marischal College and University of Aberdeen.
1857. ‡Brazill, Thomas. 12 Holles-street, Dublin.
1859. ‡Brebner, Alexander C. Audit Office, Somerset House, London, W.C.
1859. *Brebner, James. 20 Albyn-place, Aberdeen.
1860. ‡Brett, G. Salford.
1854. *Brett, John Watkins. 2 Hanover-square, London, W.
1866. §Brettell, Thomas (Mine Agent). Dudley.
1854. ‡*Brewin, Robert.*
1865. §Brewin, William. Cirencester.
‡Brewster, Sir David, K.H., LL.D., D.C.L., F.R.S. L. & E., Hon. M.R.I.A., F.G.S., F.R.A.S., Vice-Chancellor of the University of Edinburgh. Edinburgh.
1859. ‡Brewster, Rev. Henry. Manse of Farnell.
1866. *Briggs, Arthur. Rawdon, near Leeds.
*Briggs, General John, F.R.S., M.R.A.S., F.G.S. 2 Tenterden-street, London, W.
1866. §Briggs, Joseph. Ulverstone, Lancashire.
1863. *Bright, Sir Charles Tilston, C.E., F.R.G.S., F.R.A.S. 12 Upper Hyde Park-gardens, and 1 Victoria-street, Westminster, London.
Bright, John, M.P. Rochdale, Lancashire.
1863. ‡Brivit, Henri. Washington Chemical Works, Washington, Durham.
1842. Broadbent, Thomas. Marsden-square, Manchester.
1848. ‡Brock, G. B. Bryn Tyfi, Swansea.
1859. ‡Brodhurst, Bernard Edwin. 20 Grosvenor-street, Grosvenor-square, London, W.
1847. ‡Brodie, Sir Benjamin C., Bart., M.A., F.R.S., Professor of Chemistry in the University of Oxford. Cowley House, Oxford.
1834. ‡Brodie, Rev. James. Monimail, Fifeshire.
1865. ‡Brodie, Rev. Peter Bellenger, M.A., F.G.S. Rowington Vicarage, near Warwick.
1853. ‡Bromby, J. H., M.A. The Charter House, Hull.
*Bromilow, Henry G.*
1842. Brook, William. Meltham, York.
*Brooke, Charles, M.A., F.R.S. 16 Fitzroy-square, London.
1855. ‡Brooke, Edward. Marsden House, Stockport, Cheshire.
1864. *Brooke, Rev. J. T. Bannerdown House, Batheaston, Bath.
1855. ‡Brooke, Peter William. Marsden House, Stockport, Cheshire.
1863. §Brooks, John C. Wallsend, Newcastle-on-Tyne.
*Brooks, Samuel. King-street, Manchester.
1846. *Brooks, Thomas (Messrs. Butterworth and Brooks). Manchester.
Brooks, William. Ordfall-hill, East Retford, Nottinghamshire.
1847. ‡Broome, C. E. Elmhurst, Batheaston, near Bath.
1863. *Brough, Lionel H., F.G.S., one of Her Majesty's Inspectors of Coal-Mines. 38 Cornwallis Crescent, Clifton, Bristol.
*Broun, John Allan, F.R.S., Astronomer to His Highness the Rajah of Travancore.

Year of Election.

1863. ‡Brown, Alexander Crum, F.R.S.E. Arthur Lodge, Dalkeith-road, Edinburgh.
Brown, Charles Edward. Cambridge.
1855. ‡Brown, Colin. 3 Mansfield-place, Glasgow.
1863. *Brown, Rev. Dixon. Unthank Hall, Haltwhistle, Carlisle.
1858. ‡Brown, Alderman Henry. Bradford.
1865. §Brown, Edwin, F.G.S. Burton-upon-Trent.
Brown, Hugh. Broadstone, Ayrshire.
1858. ‡Brown, John. Barnsley.
1863. ‡Brown, John H. 29 Sandhill, Newcastle-on-Tyne.
1863. ‡Brown, Ralph. Lambton's Bank, Newcastle-on-Tyne.
1856. *Brown, Samuel, F.S.S. The Elms, Larkhall Rise, Clapham, London.
*Brown, Thomas. Hardwick House, Chepstow.
*Brown, William. 3 Maitland Park Villas, Haverstock-hill, London.
1855. ‡Brown, William. 179 Bath-street, Glasgow.
1850. ‡Brown, William, F.R.S.E. 25 Dublin-street, Edinburgh.
1865. ‡Brown, William. 41 *a* New-street, Birmingham.
1863. ‡Browne, B. Chapman. Tynemouth.
1854. ‡*Browne, Henry, M.D.*
1866. *Browne, Rev. J. H. Lowdham, Nottingham.
1862. *Browne, Robert Clayton, B.A. Browne's Hill, Carlow, Ireland.
Browne, William. Richmond-hill, near Liverpool.
1865. §Browne, William. The Friary, Lichfield.
1865. §Browning, John. 111 Minories, London, E.
1855. §Brownlee, James. 173 St. George's-road, Glasgow.
Brownlie, Archibald. Glasgow.
1853. ‡Brownlow, William B. Villa-place, Hull.
*Bruce, Alexander John. Kilmarnock.
1852. ‡Bruce, Rev. William. Belfast.
1851. ‡Bruff, P. Handford Lodge, Ipswich.
1863. *Brunel, H. M. Duke-street, Westminster, London.
1863. ‡Brunel, J. Duke-street, Westminster, London.
1859. ‡*Bryant, Arthur C.*
1858. ‡*Bryant, Wilberforce.*
1861. §Bryce, James. York Place, Higher Broughton, Manchester.
Bryce, James, M.A., LL.D., F.G.S. High School, Glasgow.
Bryce, Rev. R. J., LL.D., Principal of Belfast Academy. Belfast.
1850. ‡Bryson, Alexander, F.R.S.E. Hawkhill, Edinburgh.
1859. ‡Bryson, William Gillespie. Cullen, Aberdeen.
Buchanan, Andrew, M.D., Regius Professor of the Institutes of Medicine in the University of Glasgow. Glasgow.
Buchanan, Archibald. Catrine, Ayrshire.
Buchanan, D. C. Poulton cum Seacombe, Cheshire.
1850. ‡*Buchanan George.*
*Buchanan, James, R.E.*
*Buck, George Watson. Ramsay, Isle of Man.
1864. §Buckle, Rev. George, M.A. Twerton Vicarage, Bath.
1846. ‡Buckley, Colonel. New Hall, Salisbury.
1865. *Buckley. Henry. Church-road, Edgbaston. Birmingham.
1847. ‡Buckley, Rev. W. E., M.A. Middleton Cheney, Banbury.
1848. *Buckman, James, F.L.S., F.G.S., Professor of Natural History in the Royal Agricultural College, Cirencester. Bradford Abbas, Sherbourne, Dorsetshire.
1851. *Buckton, G. Bowdler, F.R.S. Weycombe, Haslemere, Surrey.
1848. ‡Budd, Edward. Hafod Works, Swansea.
1848. *Budd, James Palmer. Ystalyfera Iron Works, Swansea.
1851. ‡Bullen, George. Carr-street, Ipswich.

Year of Election.

*Buller, Sir Antony. Pound, near Tavistock, Devon.
1845. ‡Bunbury, Sir Charles James Fox, Bart., F.R.S., F.L.S., F.G.S., F.R.G.S. Barton Hall, Bury St. Edmunds.
1845. ‡Bunbury, Edward H., F.G.S. 15 Jermyn-street, London, S.W.
1865. ‡Bunce, John Mackray. 'Journal Office,' New-street, Birmingham.
Bunch, Rev. Robert James, B.D., F.C.P.S. Emanuel Rectory, Loughborough.
1863. §Bunning, T. Wood. 34 Grey-street, Newcastle-on-Tyne.
Bunt, Thomas G. Nugent-place, Bristol.
1854. ‡Burckhardt, Otte. Bank Chambers, Liverpool.
1842. *Burd, John. 37 Jewin-street, Aldersgate-street, London, E.C.
1863. *Burgess, John. Rastrick, Yorkshire.
Burgoyne, General Sir John F., Bart., G.C.B., D.C.L., F.R.S., Inspector General of Fortifications. 8 Gloucester-gardens, London.
1857. ‡Burk, J. Lardner, LL.D. 2 North Great George-street, Dublin.
1865. ‡Burke, Luke. 5 Albert-terrace, Acton, London.
1859. ‡Burnett, Newell. Belmont-street, Aberdeen.
1860. ‡Burrows, Montague, M.A., Commander R.N. Oxford.
1866. *Burton, Frederick M. Highfield, Gainsborough.
1857. ‡Busby, John. 9 Trafalgar-terrace, Monkstown, Ireland.
1864. ‡Bush, W. 7 Circus, Bath.
Bushell, Christopher. Royal Assurance-buildings, Liverpool.
1855. *Busk, George, F.R.S., Sec. L.S., F.G.S., Examiner in Comparative Anatomy in the University of London. 15 Harley-street, Cavendish-square, London, W.
1857. ‡Butt, Isaac, Q.C. 4 Henrietta-street, Dublin.
1845. ‡Butterfield, J. M. 45 Mount, York.
1861. *Butterworth, John. 58 Mosley-street, Manchester.
1855. *Buttery, Alexander W. Monkland Iron and Steel Company, Cardarroch, near Airdrie.
1845. ‡*Button, Charles.*
*Buxton, Edward North.*
1854. ‡Byerley, Isaac. Seacombe, Liverpool.
Byng, William Bateman. Orwell Works House, Ipswich.
1852. ‡Byrne, Rev. Jas. Ergenagh Rectory, Omagh, Armagh.

Cabbell, Benjamin Bond, M.A., F.R.S., F.S.A., F.R.G.S. 1 Brick-court, Temple, E.C.; and 52 Portland-place, London, W.
*Cabbell, George.*
1854. ‡*Cadell, William.*
1858. §Cail, John. Stokesley, Yorkshire.
1863. ‡Cail, Richard. The Fell, Gateshead.
1854. ‡Caine, Nathaniel. Dutton-street, Liverpool.
1858. *Caine, Rev. William, M.A. Ducie-grove, Oxford-road, Manchester.
1863. ‡Caird, Edward. Finnart, Dumbartonshire.
1861. *Caird, James Key. Finnart on Loch Long, by Gare Loch Head, Dumbartonshire.
1855. *Caird, James T. Greenock.
1857. ‡Cairnes, Prof. Queen's College, Galway.
1845. ‡Calder, Rev. William. Fairfield Parsonage, Liverpool.
Caldwell, Robert. 9 Bachelor's-walk, Dublin.
1857. ‡Callan, Rev. N. J., Professor of Natural Philosophy in Maynooth College.
1842. Callender, W. R. The Elms, Didsbury, Manchester.
1853. ‡Calver, E. K., R.N. 21 Norfolk-street, Sunderland.
1857. ‡Cameron, Charles A., M.D. 17 Ely-place, Dublin.
Cameron, John. Glasgow.

Year of Election.

1859. ‡Campbell, Rev. C. P., Principal of King's College, Aberdeen. Aberdeen.
1857. *Campbell, Dugald, F.G.S. 7 Quality-court, Chancery-lane, London.
1855. ‡Campbell, Dugald, M.D. 186 Sauchiehall-street, Glasgow.
Campbell, Sir Hugh P. H., Bart. 10 Hill-street, Berkeley-square, London, W.; and Marchmont House, near Dunse, Berwickshire.
*Campbell, Sir James. Glasgow.
Campbell, Rev. James, D.D. Forkhill, Dundalk, Ireland.
1855. ‡*Campbell, John.*
Campbell, John Archibald, F.R.S.E. Albyn-place, Edinburgh.
1852. ‡Campbell, William. Donegal-square West, Belfast.
1859. ‡Campbell, William. Dunmore, Argyllshire.
1862. *Campion, Rev. William. Queen's College, Cambridge.
1853. ‡Camps, William, M.D., F.L.S., F.R.G.S. 40 Park-street, Grosvenor-square, London, W.
Cape, Rev. Joseph, M.A., F.C.P.S. Birdbrook Rectory, Halstead, Essex.
*Carew, William Henry Pole. Antony House, near Devonport.
1861. ‡Carlton, James. Mosley-street, Manchester.
Carmichael, H. 18 Hume-street, Dublin.
Carmichael, John T. C. Messrs. Todd & Co., Cork.
*Carpenter, Philip Pearsall, B.A., Ph.D. Montreal, Canada.
1854. ‡Carpenter, Rev. R. Lant, B.A. Halifax.
1845. ‡Carpenter, William B., M.D., F.R.S., F.L.S., F.G.S., Registrar of the University of London. 56 Regent's Park Road, London, N.W.
Carpmael, William. 24 Southampton-buildings, Chancery-lane, London, E.C.
1856. ‡Carr, John. Queen's Circus, Cheltenham.
1849. ‡Carr, William. Gomersal, Leeds.
1842. *Carr, William, M.D., F.R.C.S. Lee Grove, Blackheath, Kent, S.E.
1855. ‡*Carrick, John.*
1861. *Carrick, Thomas. 37 Princess-street, Manchester.
1861. *Carson, Rev. Joseph, D.D., Fellow of Trinity College, Dublin, M.R.I.A. 18 Fitzwilliam-place, Dublin.
1857. ‡Carte, Alexander, M.D. Royal Dublin Society, Dublin.
1845. ‡Carter, G. B. Lord-street, Liverpool.
1866. §Carter, H. H. The Park, Nottingham.
1855. ‡Carter, Richard, C.E. Long Carr, Barnsley, Yorkshire.
*Cartmell, Rev. James, D.D., F.G.S., Master of Christ's Coll. Cambridge.
Cartmell, Joseph, M.D. Carlisle.
*Cartwright, Rev. R. B.*
1862. ‡Carulla, Facundo, F.A.S.L. Care of Messrs. Daglish and Co., 8 Harrington-street, Liverpool.
1866. §Casella, L. P., F.R.A.S. South Grove, Highgate, London, N.
1842. *Cassels, Rev. Andrew, M.A. Batley Vicarage, near Leeds.
Castle, Charles. Clifton, Bristol.
Castle, Robert. Cleeve Court, Bristol.
1853. ‡Cator, John B., Commander R.N. 1 Adelaide-street, Hull.
1855. ‡*Catterill, Rev. Henry.*
1859. ‡Catto, Robert. 44 King-street, Aberdeen.
1866. §Catton, Alfred R. St. John's College, Cambridge.
1849. ‡Cawley, Charles Edward. The Heath, Kirsall, Manchester.
1860. §Cayley, Arthur, F.R.S., V.P.R.A.S., Sadlerian Professor of Mathematics in the University of Cambridge. Cambridge.
Cayley, Digby. Brompton, near Scarborough.
Cayley, Edward Stillingfleet. Wydale, Malton, Yorkshire.
1858. *Chadwick, Charles, M.D. 35 Park-square, Leeds.
1860. §Chadwick, David. 64 Cross-street, Manchester.

Year of Election.

1842. Chadwick, Edwin, C.B. Richmond, Surrey.
1842. Chadwick, Elias, M.A. Pudleston-court, near Leominster.
1842. Chadwick, John. Broadfield, Rochdale.
1859. †Chadwick, Robert. Highbank, Manchester.
1861. †Chadwick, Thomas. Wilmslow Grange, Cheshire.
*Challis, Rev. James, M.A., F.R.S., F.R.A.S., Plumian Professor of Astronomy in the University of Cambridge. 13 Trumpington-street, Cambridge.
1859. †Chalmers, John Inglis. Aldbar, Aberdeen.
1859. †Chalmers, Rev. Dr. P. Dunfermline.
1865. †Chamberlain, J. H. Christ Church-buildings, Birmingham.
1842. Chambers, George. High Green, Sheffield.
Chambers, John. Ridgefield, Manchester.
*Chambers, Robert, F.R.S.E., F.L.S., F.G.S. 17 Hereford-square, Mayfair, London, W.
*Champney, Henry Nelson. St. Paul's-square, York.
1865. †Chance, A. M. Edgbaston, Birmingham.
1865. *Chance, James Simmers. Brown's Green, Handsworth, Birmingham.
1865. §Chance, Robert Lucas. Chad Hill, Birmingham.
1861. *Chapman, Edward. Frewen Hall, Oxford.
1850. †Chapman, Prof. E. J. University College; and 4 Addison-terrace, Kensington, London, W.
1866. §Chapman, E. T. Hope Cottage, Hanwell.
1861. *Chapman, John. Hill End, Mottram, Manchester.
Chapman, Captain John James, R.A., F.R.G.S. Adelaide-square, Bedford.
1866. §Chapman, William. The Park, Nottingham.
1854. †Chapple, Frederick. Canning-street, Liverpool.
Charlesworth, Edward, F.G.S. Whittington Club, Arundel-street, London, W.C.
1863. †Charlton, Edward, M.D. 7 Eldon-square, Newcastle-on-Tyne.
1863. †*Charlton, F.*
1866. §Charnock, Dr. R. S. 8 Gray's Inn-square, London, W.C.
Chatto, W. J. P. Union Club, Trafalgar-square, London, W.C.
1864. †Cheadle, W. B., M.A., M.D., F.R.G.S. 6 Hyde Park-place, Cumberland Gate, London, W.
1842. *Cheetham, David. Weston Park, Bath.
1852. †Cheshire, Edward. Conservative Club, London, S.W.
*Cheshire, John.*
1853. *Chesney, Major-General Francis Rawdon, R.A., D.C.L., F.R.S., F.R.G.S. Ballyardle, Kilkeel, Co. Down, Ireland.
*Chevallier, Rev. Temple, B.D., F.R.A.S., Professor of Mathematics and Astronomy in the University of Durham.
*Chichester, Ashhurst Turner Gilbert, D.D., Lord Bishop of. 31 Queen Anne-street, Cavendish-square, London, W.; and The Palace, Chichester.
1865. §Child, Gilbert W., M.D. Oxford.
1842. *Chiswell, Thomas. 2 Lincoln-grove, Plymouth-grove, Manchester.
1863. §Cholmeley, Rev. C. H. Magdalen College, Oxford.
1859. †Christie, John, M.D. 46 School-hill, Aberdeen.
1861. †Christie, Professor R. C., M.A. 7 St. James's-square, Manchester.
Christison, Robert, M.D., F.R.S.E., Professor of Dietetics, Materia Medica, and Pharmacy in the University of Edinburgh. Edinburgh.
1860. †Church, William Selby, M.A. 1 Harcourt Buildings, Temple, London.
1850. †Churchill, The Right Hon. Lord Alfred. Blenheim, Woodstock.
1857. †Churchill, F., M.D. 15 Stephen's Green, Dublin.
1863. †Clapham, A. 3 Oxford-street, Newcastle-on-Tyne.

Year of Election.

1863. †Clapham, Henry. 5 Summerhill-grove, Newcastle-on-Tyne.
1855. §Clapham, Robert Calvert. Wincomblee, Walker, Newcastle-on-Tyne.
1858. †Clapham, Samuel. 17 Park-place, Leeds.
1857. †Clarendon, Frederick Villiers. 11 Blessington-street, Dublin.
*Clark, Rev. Charles, M.A. Queen's College, Cambridge.
Clark, Courtney K. Haugh End, Halifax.
1859. †Clark, David. Coupar Angus.
*_Clark, Francis._
Clark, G. T. Bombay; and Athenæum Club, Pall Mall, London.
1846. *Clark, Henry, M.D. 4 Upper Moira-place, Southampton.
Clark, Sir James, Bart., M.D., M.A., F.R.S., F.R.G.S., Physician in Ordinary to the Queen. 22B Brook-street, Grosvenor-square, London, W.
1861. †Clark, Latimer. 1 Victoria-street, Westminster, London.
1855. †Clark, Rev. William, M.A. Barrhead, near Glasgow.
Clark, William, M.D., F.R.S., F.G.S. Cambridge.
1865. †Clarke, Rev. Charles. Charlotte-road, Edgbaston, Birmingham.
Clarke, George. Mosley-street, Manchester.
1861. *Clarke, J. H. Newton Villa, Newton-le-Willows, near Warrington.
1842. Clarke, Joseph. Waddington Glebe, Lincoln.
1851. †Clarke, Joshua, F.L.S. Fairycroft, Saffron Walden.
Clarke, Thomas, M.A. Knedlington Manor, Howden, Yorkshire.
1848. §Claudet, Antoine, F.R.S. 11 Gloucester-road, Regent-park, London, N.W.
1861. †Clay, Charles, M.D. 101 Piccadilly, Manchester.
*Clay, Joseph Travis, F.G.S. Rastrick, Yorkshire.
1854. †Clay, Robert. St. Ann-street, Liverpool.
1855. †_Clay, William._
1856. *Clay, William. 4 Park-hill-road, Liverpool.
1866. §Clayden, Rev. P. W. Clarendon-street, Nottingham.
1857. *Clayton, David Shaw. Norbury, Stockport, Cheshire.
1850. †Cleghorn, Hugh, M.D. Madras Establishment.
1859. †Cleghorn, John. Wick.
1861. §Cleland, John, M.D. Queen's College, Galway.
1857. †Clements, Henry. Dromin, Listowel, Ireland.
†Clerk, Rev. D. M. Deverill, Warminster, Wilts.
Clerke, Rev. C. C., D.D., Archdeacon of Oxford and Canon of Christ Church, Oxford. Milton Rectory, Abingdon, Berkshire.
1850. †_Clerke, Right Honourable Sir George, Bart._
1852. †Clibborn, Edward. Royal Irish Academy, Dublin.
1865. †Clift, John E., C.E. Redditch.
1861. *Clifton, Professor R. B., B.A. Owens College, Manchester.
1849. †Clive, R. H. Hewell, Bromsgrove.
Clonbrock, Lord Robert. Clonbrock, Galway.
1854. †Close, The Very Rev. Francis, M.A. Carlisle.
1866. §Close, Thomas. St. James's-street, Nottingham.
Clough, Rev. Alfred B., B.D. Brandeston, Northamptonshire.
1859. †Clouston, Rev. Charles. Sandwick, Orkney.
1861. *Clouston, Peter. Glasgow.
1863. §Clutterbuck, Thomas. Warkworth, Acklington.
1855. *Coats, Peter. Woodside, Paisley.
1855. *Coats, Thomas. Fergeslie House, Paisley.
Cobb, Edward. South Bank, Weston, near Bath.
1851. *Cobbold, John Chevallier, M.P. Tower-street, Ipswich.
1864. §Cobbold, T. Spencer, M.D., F.R.S., F.L.S., Lecturer on Comparative Anatomy at the Middlesex Hospital. 84 Wimpole-street, Cavendish-square, London, W.

Year of Election.

1845. †Cocker, John, M.A. Cambridge.
*Cocker, Jonathan. Higher Broughton, Manchester.
1854. †Cockey, William. 18 Lansdown-crescent, Glasgow.
1861. *Coe, Rev. Charles C. Leicester.
1864. *Cochrane, James Henry. Dunkathel, Glanmire, Co. Cork.
1865. †Coghill, H. Newcastle-under-Lyme.
1853. †Colchester, William, F.G.S. Grundesburgh Hall, Ipswich.
1859. †Cole, Edward. 11 Hyde Park-square, London, W.
1859. *Cole, Henry Warwick. 3 New-square, Lincoln's Inn, London, W.C.
1846. †Cole, Robert, F.S.A. 54 Clarendon-road, Notting-hill, London, W.
1860. †*Coleman, J. J., F.C.S.*
1854. *Colfox, William, B.A. Bridport, Dorsetshire.
1857. †Colles, William, M.D. 21 Stephen's Green, Dublin.
1861. *Collie, Alexander. 12 Kensington Palace-gardens, London, W.
1861. †*Colkinge, John.*
1854. †Collingwood, Cuthbert, M.A., M.B., F.L.S. 15 Oxford-street, Liverpool.
1861. *Collingwood, J. Frederick, F.G.S. 54 Gloucester-street, Belgrave-road, Pimlico, London, S.W.
1865. *Collins, James Tertius. 36 Cumberland-street, Birmingham.
1849. †Collins, Joseph. Frederick-street, Edgbaston, Birmingham.
Collins, Robert, M.R.D.S. Ardsallagh, Navan, Ireland.
Collis, Stephen Edward. Listowel, Ireland.
Colthurst, John. Clifton, Bristol.
1865. *Combe, Thomas, M.A. Oxford.
*Compton, Lord Alwyn. Castle Ashby, Northamptonshire.
1846. *Compton, Lord William. 145 Piccadilly, London, W.
1852. †Connal, Michael. 16 Lynedock-terrace, Glasgow.
1853. †*Constable, Sir T. C., Bart.*
1858. †Conybeare, Henry, F.G.S. 20 Duke-street, Westminster, London.
*Conway, Charles. Pontnwydd Works, Newport, Monmouthshire.
1864. *Conwell, Eugene Alfred, M.R.I.A. Trim, Ireland.
1859. †Cook, E. R. Stamford-hill, London.
1861. *†Cook, Henry.*
*Cooke, Captain Adolphus.*
*†Cooke, A. B.*
1863. †Cooke, Edward William, F.R.S., F.L.S., F.G.S., A.R.A. The Ferns, Hyde Park-gate, South Kensington, London, S.W.
Cooke, James R., M.A. 73 Blessington-street, Dublin.
1854. †Cooke, John. Howe Villa, Richmond, Yorkshire.
Cooke, J. B. Exchange-buildings, Liverpool.
Cooke, Rev. T. L., M.A. Magdalen College, Oxford.
1854. †Cooke, Rev. William, M.A. Gazeley Vicarage, near Newmarket.
Cooke, William Fothergill. Telegraph Office, Lothbury, London, E.C.
1859. *Cooke, William Henry, M.A., F.S.A. Elm-court, Temple, London, E.C.
1865. †Cooksey, Joseph. West Bromwich, Birmingham.
1862. *Cookson, Rev. H. W., D.D. St. Peter's College, Cambridge.
1863. †Cookson, N. C. Benwell Tower, Newcastle-on-Tyne.
1850. †Cooper, Sir Henry, M.D. 7 Charlotte-street, Hull.
Cooper, James. 55 Pembroke Villas, Bayswater, London, W.
1846. †Cooper, William White. 19 Berkeley-square, London, W.
1865. §Cope, James. Pensnett, near Dudley.
1856. †Copeland, George F., F.G.S., 5 Bay's-hill Villas, Cheltenham.
1854. †Copland, James, M.D., F.R.S. 5 Old Burlington-street, London, W.
Copland, William, F.R.S.E. Dumfries.
1863. †Coppin, John. North Shields.
1842. *Corbet, Richard. Hadington-hill, Oxford.
1842. Corbett, Edward. Ravenoak, Cheadle-hulme, Cheshire.

Year of Election.

1855. ‡Corbett, Joseph Henry, M.D., Professor of Anatomy and Physiology, Queen's College, Cork.
Cormack, John Rose, M.D., F.R.S.E. 5 Bedford-square, London.
1860. ‡*Corner, C. Tinsley.*
Cory, Rev. Robert, B.D., F.C.P.S. Stanground, Peterborough.
Cottam, George. 2 Winsley-street, London, W.
1857. ‡Cottam, Samuel. Brazennose-street, Manchester.
*Cotter, John. Cork.*
1864. §Cotton, General Frederick C. Knolton Hall, Ruabon.
**Cotton, Rev. William Charles, M.A. New Zealand.*
Couper, James. 12 Royal Exchange-square, Glasgow.
1865. §Courtald, Samuel. Gosfield Hall, Essex.
*Courtney, Henry, M.R.I.A. 24 Fitzwilliam-place, Dublin.
Cowan, John. Valleyfield, Pennycuick, Edinburgh.
1863. ‡Cowan, John A. Blaydon Burn, Durham.
1863. ‡Cowan, Joseph, jun. Blaydon, Durham.
Cowie, Rev. Benjamin Morgan, M.A. 42 Upper Harley-street, Cavendish-square, London, W.
1860. ‡*Cowper, Edward Alfred, M.I.C.E.*
1850. ‡Cox, John. Georgie Mills, Edinburgh.
Cox, Robert. 26 Rutland-street, Edinburgh.
1866. §Cox, William. 50 Newhall-street, Birmingham.
1847. ‡Cox, Rev. W. H., B.D. Eaton Bishop, Herefordshire.
1854. §Crace-Calvert, Frederick, Ph.D., F.R.S., F.C.S., Honorary Professor of Chemistry to the Manchester Royal Institution. Royal Institute, Manchester.
Craig, J. T. Gibson, F.R.S.E. Edinburgh.
1859. ‡Craig, S. Clayhill, Enfield, Middlesex.
1857. ‡Crampton, Rev. Josiah., M.R.I.A. The Rectory, Florence-court, Co. Fermanagh, Ireland.
1858. ‡Cranage, Edward, Ph.D. The Old Hall, Wellington, Shropshire.
*Craven, Robert. Hull.*
1852. ‡Crawford, Alexander, jun. Mount Prospect, Belfast.
1857. ‡*Crawford, George Arthur, M.A.*
1849. ‡Crawfurd, John, F.R.S., F.R.G.S. 4 Elvaston-place, Kensington, W.; and Athenæum Club, Pall Mall, London, S.W.
1842. *Crewdson, Thomas D. Dacca Mills, Manchester.
Creyke, The Venerable Archdeacon. Beeford Rectory, Driffield.
*Crichton, William. 1 West India-street, Glasgow.
1854. ‡*Crisp, M. F.*
1865. ‡Crocker, Edwin, F.C.S. 2 Lonsdale-square, Islington, London, N.
*Croft, Rev. John, M.A., F.C.P.S.*
1858. ‡Crofts, John. Hillary-place, Leeds.
Croker, Charles Phillips, M.D., M.R.I.A. 7 Merrion-square West, Dublin.
1859. ‡Croll, A. A. 10 Coleman-street, London.
1857. ‡Crolly, Rev. George. Maynooth College, Ireland.
1855. ‡Crompton, Charles, M.A. 22 Hyde Park-square, London, W.
*Crompton, Rev. Joseph, M.A. Norwich.
1866. §Cronin, William. 4 Brunel-terrace, Nottingham.
*Crook, J. Taylor.*
*Crook, William Henry, LL.D.*
1865. §Crookes, William, F.R.S., F.C.S. 20 Mornington-road, Regent's Park, London, N.W.
1855. *Cropper, Rev. John. Stand, near Manchester.
1859. ‡Crosfield, John. Rothay Bank, Ambleside.
1861. ‡Cross, Rev. John Edward, M.A. Appleby Vicarage, near Brigg.
1853. ‡Crosskill, William, C.E. Beverley, Yorkshire.

Year of Election.

1866. *Crossley, Louis J., F.M.S., M.R.S., Willow Hall, near Halifax.
1865. §Crotch, George Robert. 8 Pearl-street, Cambridge.
1854. ‡Crowe, John. 3 Mersey Chambers, Liverpool.
1861. §Crowley, Henry. 255 Cheetham-hill-road, Manchester.
1863. §Crowther, B. Wakefield.
1863. ‡Cruddas, George. Elswick Engine Works, Newcastle-on-Tyne.
1860. ‡Cruickshank, John. City of Glasgow Bank, Aberdeen.
1859. ‡Cruickshank, Provost. Macduff, Aberdeen.
1859. ‡Crum, James. Busby, Glasgow.
1855. §Crum, Walter, F.R.S., F.C.S. 4 West Regent Street, Glasgow.
1849. ‡Cubitt, Thomas. Thames Bank, Pimlico, London, S.W.
1851. ‡Cull, Richard. 13 Tavistock-street, Bedford-square, London, W.C.
Culley, Robert. Bank of Ireland, Dublin.
1859. ‡Cumming, Sir A. P. Gordon, Bart. Altyre.
1847. ‡*Cumming, Rev. J. G., M.A.*
1861. *Cunliffe, Edward Thomas. Handforth, Manchester.
1861. *Cunliffe, Peter Gibson. Handforth, Manchester.
1850. ‡Cunningham, James. 50 Queen-street, Edinburgh.
1861. ‡Cunningham, James, F.R.S.E. Queen-street, Edinburgh.
*Cunningham, John. Liverpool.*
1852. ‡Cunningham, John. Macedon, near Belfast.
1850. ‡Cunningham, Rev. William, D.D. 17 Salisbury-road, Edinburgh.
1855. §Cunningham, William A. Manchester and Liverpool District Bank, Manchester.
1850. ‡Cunningham, Rev. W. B. Prestonpans, Scotland.
1866. §Cunnington, John. 68 Oakley-square, Bedford New Town, London, N.W.
1857. ‡Curtis, Professor Arthur Hill, LL.D. 6 Trinity College, Dublin.
1866. §Cusins, Rev. F. L. 26 Addison-street, Nottingham.
1834. *Cuthbert, J. R. 40 Chapel-street, Liverpool.
Cuthbertson, Allan. Glasgow.

1863. ‡Daglish, John. Hetton, Durham.
1854. ‡Daglish, Robert, C.E. Orrell Cottage, near Wigan.
1854. ‡Daglish, Robert, jun. St. Helen's, Lancashire.
1863. ‡Dale, J. B. South Shields.
1853. ‡Dale, Rev. P. Steele, M.A. Hollingfare, Warrington.
1865. ‡Dale, Rev. R. W. 12 Calthorpe-street, Birmingham.
Dalmahoy, James, F.R.S.E. 9 Forres-street, Edinburgh.
1850. ‡Dalmahoy, Patrick. 69 Queen-street, Edinburgh.
1859. ‡Dalrymple, Charles Elphinstone. West Hall, Aberdeenshire.
1859. ‡Dalrymple, Colonel. Troup, Scotland.
Dalton, Edward, LL.D., F.S.A. Dunkirk House, Nailsworth.
*Dalton, Rev. James Edward, B.D. Seagrave, Loughborough.
1859. ‡*Daly, Lieut.-Colonel H. D.*
1859. *Dalzell, Allen, M.D. The University, Edinburgh.
Dalziel, John, M.D. Holm of Drumlanrig, Thornhill, Dumfriesshire.
1862. ‡Danby, T. W. Downing College, Cambridge.
1859. ‡Dancer, J. B., F.R.A.S. Old Manor House, Ardwick, Manchester.
*Daniel, Henry, M.D.*
1847. ‡*Danson, John Towne.*
1849. *Danson, Joseph, F.C.S. 6 Shaw-street, Liverpool.
Danson, William. 6 Shaw-street, Liverpool.
1859. §Darbishire, Charles James. Rivington, near Chorley, Lancashire.
1861. *Darbishire, Robert Dukinfield, B.A., F.G.S. 21 Brown-street, Manchester.
*Darbishire, Samuel D. Pendyffryn, near Conway.

Year of Election.

1852. ‡*Darby, Rev. Jonathan L.*
Darwin, Charles R., M.A., F.R.S., F.L.S., F.G.S. Down, near Bromley, Kent.
1854. ‡*Dashwood, Charles.*
1848. §Da Silva, Johnson. Burntwood, Wandsworth Common.
*Daubeny, Charles Giles Bridle, M.D., LL.D., F.R.S., F.L.S., F.G.S., M.R.I.A., V.P.C.S., Professor of Botany in the University of Oxford. Oxford.
1859. ‡Daun, Robert, M.D., F.G.S., Deputy Inspector-General of Hospitals. The Priory, Aberdeen.
Davey, Richard, M.P., F.G.S. Redruth, Cornwall.
1859. ‡Davidson, Charles. Grove House, Auchmull, Aberdeen.
1859. ‡Davidson, Patrick. Inchmarlo, near Aberdeen.
1847. ‡*Davidson, Rev. Samuel, LL.D.*
1863. ‡Davies, Griffith. 17 Cloudesley-street, Islington, London, N.
Davies, John Birt, M.D. The Laurels, Edgbaston, Birmingham.
1842. Davies, Dr. Thomas. Chester.
1864. §Davis, Charles E., F.S.A. 55 Pulteney-street, Bath.
Davis, Rev. David, B.A. Lancaster.
1856. *Davis, Sir John Francis, Bart., K.C.B., F.R.S., F.R.G.S. Hollywood, Compton Greenfield, near Bristol.
1859. ‡Davis, J. Barnard, M.D., F.S.A. Shelton, Staffordshire.
1859. *Davis, Richard, F.L.S. 9 St. Helen's-place, London, E.C.
1863. *Davison, Joseph. Greencroft, Durham.
1864. §Davison, Richard. Great Driffield, Yorkshire.
1857. ‡Davy, Edmund W., M.D. Kimmage Lodge, Roundtown, near Dublin.
1860. §Davy, John, M.D., F.R.S. L. & E. Lesketh How, near Ambleside.
1854. *Dawbarn, William. Wisbeach, Cambridgeshire.
1859. ‡*Dawes, Captain (Adjutant R.A. Highlanders).*
Dawes, John Samuel, F.G.S. Smethwick House, near Birmingham.
1860. *Dawes, John T., jun. Smethwick House, near Birmingham.
*Dawes, Rev. William Rutter, F.R.A.S. Haddenham, near Thame, Oxon.
1864. ‡Dawkins, W. Boyd, B.A. 2 Bexley-road, Belvedere, Kent.
*Dawson, Christopher H. Low Moor, Bradford, Yorkshire.
1865. ‡Dawson, George, M.A. Shenstone, Lichfield.
*Dawson, Henry. 14 St. James's-road, Liverpool.
1855. ‡Dawson, J. W., LL.D., F.R.S., Principal of College, Montreal, Canada.
Dawson, John. Royds Hall, Bradford, Yorkshire.
*Dawson, Thomas. Glasgow.*
1859. *Dawson, William G. Plumstead Common, Kent.
1865. ‡Day, Edward Charles H. Charmouth, Dorset.
1861. ‡Deacon, Henry. Runcorn Gap, Cheshire.
1859. ‡Dean, David. Banchory, Aberdeen.
1861. ‡Dean, Henry. Colne, Lancashire.
1854. §Deane, Henry, F.L.S. Clapham Common, London, S.
*Deane, Sir Thomas. Kingstown, Co. Dublin.
1866. §Debus, H. Queen's Wood, Hampshire.
1851. ‡De Grey, The Hon. F. Copdock, Ipswich.
*De Grey and Ripon, George Frederick, Earl, F.R.S. 1 Carlton-gardens, London, S.W.
1854. *De la Rue, Warren, Ph.D., F.R.S., F.R.A.S. Cranford, Middlesex; and 110 Bunhill-row, London, E.C.
Denchar, John. Morningside, Edinburgh.
1854. ‡Denison, The Hon. William, M.P. Grinston, Tadcaster.
Denison, Sir William Thomas, Lieut.-Col. R.E., F.R.S., F.R.G.S., Governor of Madras. Madras.
1847. ‡*Dennis, J. C., F.R.A.S.*

Year of Election.

*Dent, Joseph. Ribston Hall, Wetherby.
Dent, William Yerbury. Royal Arsenal, Woolwich, S.E.
De Saumarez, Rev. Havilland, M.A. St. Peter's Rectory, Northampton.
De Tabley, George, Lord, F.Z.S. Tabley House, Knutsford, Cheshire.
*Devonshire, William, Duke of, K.G., M.A., LL.D., F.R.S., F.G.S., F.R.G.S., Chancellor of the University of Cambridge. Devonshire House, Piccadilly, London, W.; and Chatsworth, Derbyshire.
1859. ‡Dewar, Rev. D., D.D., LL.D., Principal of Marischal College, Aberdeen.
1858. ‡Dibb, Thomas Townend. Little Woodhouse, Leeds.
1850. ‡Dick, Professor William. Veterinary College, Edinburgh.
1854. ‡Dicker, J. R. 29 Exchange-alley North, Liverpool.
1852. ‡Dickie, G., M.D., Professor of Natural History in Queen's College, Belfast.
1864. *Dickinson, F. H. Wingweston, Somerton, Taunton.
1863. ‡Dickinson, G. T. Claremont-place, Newcastle-on-Tyne.
1853. *Dickinson, Joseph, M.D., F.R.S. 92 Bedford-street South, Liverpool.
1861. *Dickinson, W. L. 1 St. James's-street, Manchester.
1848. ‡Dickson, Peter. 28 Upper Brook-street, London, W.
1863. *Dickson, William, Clerk of the Peace for Northumberland. Alnwick, Northumberland.
*Dikes, William Hey, F.G.S. Wakefield.
*Dilke, Sir C. Wentworth, Bart., F.L.S., F.G.S., F.R.G.S. 76 Sloane-street, London.
1862. *Dilke, Charles Wentworth. 76 Sloane Street, London, S.W.
1848. ‡Dillwyn, Lewis Llewelyn, M.P., F.L.S., F.G.S. Parkwern, near Swansea.
1859. *Dingle, Rev. J. Lanchester, Durham.
Dircks, Henry, C.E., F.C.S. 48 Charing Cross, London, W.C.
1853. ‡Dixon, Edward, M.Inst.C.E. Wilton House, Southampton.
1854. ‡Dixon, Hugh. Devonshire House, Birkenhead.
1865. ‡Dixon, L. Hooton, Cheshire.
1858. ‡*Dixon, Isaiah.*
Dixon, Rev. W. H. Bishopthorpe, near York.
1861. ‡Dixon, W. Hepworth, F.S.A., F.R.G.S. Essex-villas, Queen's-road, St. John's-wood, London.
1859. ‡*Dixon, William Smith.*
*Dobbin, Leonard, jun., M.R.I.A. 27 Gardiner's-place, Dublin.
1851. ‡Dobbin, Orlando T., LL.D., M.R.I.A. Ballivor, Kells, Co. Meath.
1860. ‡Dobbs, Archibald Edward. Balliol College, Oxford.
1864. *Dobson, William. Oakwood, Bathwick-hill, Bath.
Dockray, Benjamin. Lancaster.
1857. ‡Dodds, Thomas W., C.E. Rotherham.
*Dodsworth, Benjamin. St. Leonard's-place, York.
*Dodsworth, George. Clifton-grove, near York.
Dolphin, John. Delves House, Berry Edge, near Gateshead.
1851. ‡Domvile, William C., F.Z.S. Thorn-hill, Bray, Dublin.
*Donisthorpe, George Edmund. Holly Bank, Moortown, Leeds.
1860. ‡Donkin, William Fishburn, M.A., F.R.S., F.R.A.S., Savilian Professor of Astronomy in the University of Oxford. 34 Broad-street, Oxford.
1861. ‡Donnelly, Captain, R.E. South Kensington Museum, London, W.
1857. *Donnelly, William, C.B., Registrar-General for Ireland. Auburn, Malahide, Ireland.
1857. ‡Donovan, M., M.R.I.A. Clare-street, Dublin.
1863. ‡Doubleday, Thomas. 25 Ridley-place, Newcastle-upon-Tyne.

Year of Election.

1863. *Doughty, C. Montague. Downing College, Cambridge.
Douglas, James. Cavers, Roxburghshire.
1855. §Dove, Hector, F.G.S. Rose Cottage, Trinity, near Edinburgh.
Downall, Rev. John. Okehampton, Devon.
1857. ‡Downing, S., LL.D., Professor of Civil Engineering in the University of Dublin. Dublin.
1865. *Dowson, E. Theodore. Geldestone, near Beccles, Suffolk.
1852. ‡Drennan, Dr. Chichester-street, Belfast.
Drennan, William, M.R.I.A. 35 North Cumberland-street, Dublin.
1865. ‡Drew, Robert A. 6 Stanley-place, Duke-street, Broughton, Manchester.
*Drummond, David. Stirling.*
Drummond, H. Home, F.R.S.E. Blair Drummond, Stirling.
1858. ‡Drummond, James. Greenock.
1859. ‡Drummond, Robert. 17 Stratton-street, London, W.
1866. *Dry, Thomas. 12 Gloucester-road, Regent's Park, London.
1863. ‡Dryden, James. South Benwell, Northumberland.
1856. *Ducie, Henry John Reynolds Moreton, Earl of, F.R.S. 1 Belgrave-square, London, S.W.; and Tortworth-court, Wotton-under-Edge.
1835. ‡*Duckett, Joseph F.*
1846. ‡Duckworth, William. Beechwood, near Southampton.
1852. ‡Dufferin, The Rt. Hon. Lord. Highgate, London; and Clandeboye, Belfast.
1859. *Duncan, Alexander. Rhode Island, United States.
1859. ‡Duncan, Charles. 52 Union-place, Aberdeen.
*Duncan, James, M.D. Farnham House, Finglass, Co. Dublin.
1866. *Duncan, James. 9 Mincing-lane, London, E.C.
1861. ‡*Duncan, James. Greenock.*
‡*Duncan, John W.*
Duncan, J. F., M.D. 19 Gardiner's-place, Dublin.
*Duncan, W. Henry, M.D. Liverpool.*
1848. ‡*Dundas, Colonel, R.A.*
*Dundas, Major-General Robert.*
Dunlop, Alexander. Clober, Milngavie, near Glasgow.
1853. *Dunlop, William Henry. Annan-hill, Kilmarnock.
1865. §Dunn, David. Annet House, Skelmorlie, by Greenock, N.B.
§Dunn, Robert, F.R.C.S. 31 Norfolk-street, Strand, London W.C.
Dunnington-Jefferson, Rev. Joseph, M.A., F.C.P.S. Thicket Hall, York.
1857. ‡Du Noyer, George V. 51 Stephen's Green, Dublin.
*Dunraven, Edwin, Earl of, F.R.S., F.R.A.S., F.G.S., F.R.G.S. Adare Manor, Co. Limerick; and Dunraven Castle, Glamorganshire.
1859. ‡Duns, Rev. John, F.R.S.E. Torphichan, Bathgate, N. B.
1852. ‡Dunville, William. Richmond Lodge, Belfast.
1849. ‡Duppa, Duppa. Church Stretton, Shropshire.
1866. §Duprey, Perry. Woodbury Down, Stoke Newington, London, N.
1860. ‡Durham, Arthur Edward, F.R.C.S., F.L.S., Demonstrator of Anatomy, Guy's Hospital, London, S.E.
Durnford, Rev. R. Middleton, Lancashire.
1851. ‡Durrant, C. M., M.D. Rushmere, Ipswich.
1857. ‡Dwyer, Henry L., M.A., M.B. 67 Upper Sackville-street, Dublin.
Dykes, Robert. Kilmorie, Torquay, Devon.

1861. ‡Eadson, Richard. 13 Hyde-road, Manchester.
1864. ‡Earle, Rev. A. Rectory, Monkton Farleigh, Bath.
*Earle, Charles, F.G.S.*
*Earnshaw, Rev. Samuel, M.A. Broomfield, Sheffield.
1863. §Easton, James. Nest House, near Gateshead, Durham

Year of Election.

Eaton, Rev. George, M.A. The Pole, Northwich.
Ebden, Rev. James Collett, M.A., F.R.A.S., F.C.P.S. Great Stukeley Vicarage, Huntingdonshire.
1861. ‡Ecroyd, William Farrer. Spring Cottage, near Burnley.
*Eddison, Edwin. Headingley-hill, Leeds.
1858. *Eddison, Francis. North Laiths, Ollerton, Newark.
*Eddy, James R., F.G.S. Carleton Grange, Skipton.
Eden, Thomas. Riversdale-road, Aigburth, Liverpool.
1852. ‡Edgar, Rev. —, D.D. University-square, Belfast.
1861. ‡Edge, John William. Percy-street, Hulme, Manchester.
*Edgeworth, Michael P., F.L.S., F.R.A.S. Mastrim House, Anerley, London, S.
1855. ‡*Edington, Thomas.*
1855. ‡Edmiston, Robert. Elmbank-crescent, Glasgow.
1859. ‡Edmond, James. Cardens Haugh, Aberdeen.
1853. **Edmondston, Rev. John.*
*Edwards, James, B.A.*
Edwards, John. Halifax.
1855. *Edwards, J. Baker, Ph.D. Royal Institution Laboratory, Liverpool.
*Egerton, Sir Philip de Malpas Grey, Bart., M.P., F.R.S., F.G.S. Oulton Park, Tarporley, Cheshire.
Egginton, Samuel Hall. North Ferriby, Yorkshire.
1859. *Eisdale, David A., M.A. 38 Dublin-street, Edinburgh.
1854. ‡Elcum, Charles Frederick. 3 Crescent-terrace, Cheltenham.
1855. ‡Elder, David. 19 Paterson-street, Glasgow.
1858. ‡Elder, John. 12 Centre-street, Glasgow.
Ellacombe, Rev. H. T., F.S.A. Bilton, near Bristol.
1863. ‡Ellenberger, J. L. Worksop.
1855. §Elliot, Robert. Wolflee, Hawick.
1861. *Elliot, Sir Walter, F.L.S. Wolflee, Hawick.
1864. ‡Elliott, E. B. Washington, United States.
1862. §Elliott, Frederick Henry, M.A. 449 Strand, London, W.C.
Elliott, John Fogg. Elvet-hill, Durham.
1859. ‡Ellis, Henry S., F.R.A.S. Fair Park, Exeter.
1857. ‡Ellis, Hercules. Lisnaroc, Clones, Ireland.
1864. *Ellis, Alexander John, B.A., F.R.S. 25 Argyll-road, Kensington, London, W.
1864. *Ellis, Joseph. Brighton.
1864. §Ellis, J. W. High House, Thornwaite, Ripley, Yorkshire.
*Ellis, Rev. Robert, A.M. Grimstone House, near Malton, Yorkshire.
Ellman, Rev. E. B. Berwick Rectory, near Lewes, Sussex.
1862. ‡Elphinstone, H. W., M.A., F.L.S. Cadogan-place, London, S.W.
Eltoft, William. Care of J. Thompson, Esq., 30 New Cannon-street, Manchester.
1856. ‡*Elwait, Mons., LL.D.*
1863. ‡Embleton, Dennis, M.D. Northumberland-street, Newcastle-upon-Tyne
1863. ‡Emery, Rev. W., B.D. Corpus Christi College, Cambridge.
1858. ‡Empson, Christopher. Headingley, near Leeds.
1866. §Enfield, Richard. Low Pavement, Nottingham.
1866. §Enfield, William. Low Pavement, Nottingham.
1853. ‡English, Edgar Wilkins. Yorkshire Banking Company, Lowgate, Hull.
Enniskillen, William Willoughby, Earl of, D.C.L., F.R.S., M.R.I.A., F.G.S. 32A Mount-street, Grosvenor-square, London, S.W.; and Florence Court, Fermanagh, Ireland.
*Enys, John Samuel, F.G.S. Enys, Cornwall.
*Erle, Rev. Christopher, M.A., F.G.S. Hardwick Rectory, near Aylesbury

Year of Election.

1864. *Eskrigge, R. A. 24 Albany, Old Hall-street, Liverpool.
1862. *Esson, William, M.A. Ness House, Cheltenham.
Estcourt, Rev. W. J. B. Long Newton, Tetbury.
*Eustace, John, M.D.*
1865. *Evans, Rev. Charles, M.A. King Edward's School, New-street, Birmingham.
1854. ‡Evans, Edward. Rock Ferry, Liverpool.
1849. *Evans, George Fabian, M.D. Waterloo-street, Birmingham.
1848. §Evans, Griffith F. D., M.D. Trewern, near Welshpool, Montgomeryshire.
1861. *Evans, John, F.R.S., F.S.A., F.G.S. Nash Mills, Hemel Hempstead.
1865. §Evans, Sebastian, M.A. Highgate, near Birmingham.
1866. §Evans, Thomas. Belper, Derbyshire.
1865. *Evans, William. Chad-road, Edgbaston, Birmingham.
Evanson, R. T., M.D. Holme Hurst, Torquay.
1854. ‡Everest, A. M. Robert. 11 Reform Club, London, S.W.
1863. *Everitt, George Allen, F.R.G.S., Belgian Consul. Birmingham.
Ewart, William, 6 Cambridge-square, Hyde Park, London, W.; and Broadlands, Devizes.
1859. *Ewing, Archibald Orr. Clermont House, Glasgow.
1855. *Ewing, William. 209 Brandon-place, West George-street, Glasgow.
1846. *Eyre, George Edward, F.G.S., F.R.G.S. 59 Lowndes-square, Knightsbridge, London; and Warren's, near Lyndhurst, Hants.
1866. §Eyre, Major-General. Athenæum Club, Pall Mall, London, S.W.
Eyton, Charles. Hendred House, Abingdon.
1849. ‡Eyton, T. C. Eyton, near Wellington, Salop.

1842. Fairbairn, Thomas. Manchester.
*Fairbairn, William, C.E., LL.D., F.R.S., F.R.G.S. Manchester.
1866. §Fairbank, F. R., M.A. St. Mary's-terrace, Hulme, Manchester.
1865. ‡Fairley, Thomas. Medical School, Leeds.
1864. ‡Falkner, F. H. Lyncombe, Bath.
Fannin, John, M.A. 41 Grafton-street, Dublin.
*Faraday, Michael, D.C.L., LL.D., F.R.S., M.R.I.A., Fullerian Professor of Chemistry in the Royal Institution of Great Britain. 21 Albemarle-street, London, W.
1859. ‡Farquharson, Robert O. Houghton, Aberdeen.
1861. §Farr, William, M.D., D.C.L., F.R.S., Superintendent of the Statistical Department General Registry Office, London. Southlands, Bickley, Kent.
1866. *Farrar, Rev. Frederick William, M.A., F.R.S. Harrow.
1857. ‡Farrelly, Rev. Thomas. Royal College, Maynooth.
1859. *Faulkner, Charles, F.S.A., F.G.S., F.R.G.S. Museum, Deddington, Oxon.
1859. *Fawcett, Henry, M.P., Professor of Political Economy in the University of Cambridge. Trinity Hall, Cambridge.
1854. ‡*Fawcett, John.*
1863. ‡Fawcus, George. Alma-place, North Shields.
1833. Fearon, John Peter. Cuckfield, Sussex.
1845. ‡Felkin, William, F.L.S. The Park, Nottingham.
Fell, John B. Ulverston, Lancashire.
1864. §Fellowes, Frank P. 8 The Green, Hampstead, London, N.W.
1852. ‡Fenton, Samuel Greame. 9 College-square, Belfast; and Keswick, near Belfast.
1855. ‡Ferguson, James. Gas Coal-works, Lesmahago, Glasgow.
1859. ‡Ferguson, John. Cove, Nigg, Inverness.
1855. ‡*Ferguson, Peter.*
1857. ‡Ferguson, Samuel. 20 North Great George-street, Dublin.

Year of Election.

1854. ‡Ferguson, William, F.L.S., F.G.S. 2 St. Aiden's-terrace, Birkenhead.
1863. *Fernie, John. Clarence Iron Works, Leeds.
Ferrall, J. M., M.D., M.R.I.A. 35 Rutland-square, Dublin.
1862. ‡Ferrers, Rev. N. M., M.A. Caius College, Cambridge.
Ferrier, Alexander James. 69 Leeson-street, Dublin.
Field, Edwin W. 36 Lincoln's Inn Fields, London, W.C.
Fielding, G. H., M.D. Tunbridge, Kent.
1854. ‡Fielding, James. Mearclough Mill, Sowerby Bridge, near Halifax.
1864. ‡Finch, Frederick, George, B.A., F.G.S. Blackheath Park, London.
Finch, John. Bridge Work, Chepstow.
Finch, John, jun. Bridge Work, Chepstow.
1859. ‡Findlay, Alexander George, F.R.G.S. 53 Fleet-street, London, E.C.; and Hayes, Kent.
1863. ‡Finney, Samuel. Sheriff-hill Hall, Newcastle-upon-Tyne.
Firth, Thomas. Northwick.
1854. ‡*Fischel, Rev. Arnold, D.D.*
1851. *Fischer, William L. F., M.A., Professor of Natural Philosophy in the University of St. Andrews, Scotland.
1858. ‡Fishbourne, Captain E. G., R.N., F.R.G.S. 6 Welamere-terrace, Paddington, London, W.
Fisher, Rev. John Hutton, M.A., F.G.S., F.C.P.S. Kirkby Lonsdale, Westmoreland.
1858. ‡Fishwick, Captain Henry. Carr-hill, Rochdale.
1857. ‡Fitzgerald, The Right Hon. Lord Otho. 13 Dominick-street, Dublin.
1857. ‡Fitzpatrick, Thomas, M.D. 31 Lower Bagot-street, Dublin.
Fitzwilliam, Hon. George Wentworth, M.P., F.R.G.S. 19 Grosvenor-square, London, S.W.; and Wentworth House, Rotherham.
1865. ‡Fleetwood, D. J. 45 George Street, St. Paul's, Birmingham.
Fleetwood, Sir Peter Hesketh, Bart. Rossall Hall, Fleetwood, Lancashire.
1850. ‡Fleming, Professor Alexander, M.D. 20 Temple Row, Birmingham.
Fleming, Christopher, M.D. Merrion-square North, Dublin.
1842. *Fleming, John, M.A.*
1855. ‡*Fleming, John.*
Fleming, John G., M.D. 155 Bath-street, Glasgow.
*Fleming, William, M.D. Rowton Grange, near Chester.
Fletcher, Edward. 4 India-buildings, Liverpool.
1853. ‡Fletcher, Isaac, F.R.S., F.R.A.S. Tarn Bank, Workington.
Fletcher, T. B. E., M.D. 7 Waterloo-street, Birmingham.
*Flood, Rev. James Charles.*
1862. ‡Flower, William Henry, F.R.S., F.L.S., F.G.S., F.R.C.S. Royal College of Surgeons, Lincoln's Inn-fields, London, W.C.
1866. §Flowers, J. W. Park Hill, Croydon, Surrey.
1854. *Forbes, David, F.R.S., F.G.S. 12 York-place, Portman-square, London, W.
*Forbes, George, F.R.S.E.*
*Forbes, James David, LL.D., F.R.S. L. & E., F.G.S., Principal of the United Colleges of St. Salvator and St. Leonards, St. Andrews. Pitlochrie.
1855. ‡Forbes, Rev. John. Symington Manse, Biggar, Scotland.
1855. ‡Forbes, Rev. John, D.D. 150 West Regent-street, Glasgow.
Forbes, Sir John Stuart, Bart., F.R.S.E. Fettercairne House, Kincardineshire.
1856. ‡Forbes, Colonel Jonathan. 12 Lansdowne-terrace, Cheltenham.
Ford, H. R. Morecombe Lodge, Yealand Congers, Lancashire.
1866. §Ford, William. Hartsdown Villa, Kensington Park Gardens East, London, W.

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Year of Election.

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1865. §Foster, Balthazar W., M.D., F.L.S. 4 Old Square, Birmingham,
1865. *Foster, Clement Le Neve, D.Sc., F.G.S. Royal Institution, Truro.
1845. ‡Foster, Ebenezer. The Elms, Cambridge.
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1845. ‡Foster, John N. St. Andrews, Biggleswade.
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1859. §Foster, Peter Le Neve, M.A. Society of Arts, Adelphi, London, W.C.
1863. ‡Foster, Robert. 30 Rye-hill, Newcastle-upon-Tyne.
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1866. §Fowler, George. Ashby.
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*Fowler, Robert. Rahinstown, Co. Meath, Ireland.
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1842. *Fox, Charles. Trebah, Falmouth.
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*Fox, Joseph Hayland. Wellington, Somerset.
1860. ‡Fox, Joseph John. Church-row, Stoke Newington, London, N.
*Fox, Robert Barclay. Falmouth.
Fox, Robert Were, F.R.S. Falmouth.
1866. **Francis, G. B. London.*
1848. ‡Francis, George Grant, F.S.A. Burrows Lodge, Swansea.
Francis, William, Ph.D., F.L.S., F.G.S., F.R.A.S. Red Lion-court, Fleet-street, London, E.C.; and 1 Matson Villas, Marsh-gate, Richmond, Surrey.
1846. ‡Frankland, Edward, Ph.D., F.R.S., Professor of Chemistry in the Royal Institution and St. Bartholomew's Hospital. 42 Park-road, St. John's Park, Haverstock-hill, London, N.W.
*Frankland, Rev. Marmaduke Charles. Chowbent, near Manchester.
Franks, Rev. J. C., M.A. Whittlesea, near Peterborough.
1859. ‡Fraser, George B. Dundee.
Fraser, James. 25 Westland-row, Dublin.
Fraser, James William. 8A Kensington Palace-gardens, London, W.
1865. *Fraser, John, M.A., M.D. 30 Darlington-street, Wolverhampton.
1859. *Frazer, Daniel. 113 Buchanan-street, Glasgow.
1860. ‡Freeborn, Richard Fernandez. 38 Broad-street, Oxford.
1847. *Freeland, Humphrey William, F.G.S. The Athenæum Club, Pall Mall, London.
1865. §Freeman, James. 15 Francis-road, Edgbaston, Birmingham.
1855. ‡*Frere, Captain, R.A.*
Frere, George Edward, F.R.S. Royden Hall, Diss, Norfolk.
1856. *Frerichs, John Andrew. 1 Keynsham Bank, Cheltenham.
*Fripp, George D., M.D.*
1857. *Frith, Richard Hastings, C.E. 51 Leinster-road, Rathmines, Dublin.
1863. *Frith, William. Burley Wood, near Leeds.

Year of Election.

Frost, Charles, F.S.A. Hull.
1847. ‡Frost, William, F.R.A.S. Wentworth Lodge, Upper Tulse-street.
1860. *Froude, William. Emsleigh Paignton, Torquay.
Fry, Francis. Cotham, Bristol.
Fry, Richard. Cotham, Bristol.
Fry, Robert. Tockington, Gloucestershire.
1863. ‡Fryar, Mark. Eaton Moor Colliery, Newcastle-on-Tyne.
*Fullarton, Allan. 19 Woodside-place, Glasgow.
1859. ‡Fuller, Frederick, M.A., Professor of Mathematics in University and King's College, Aberdeen.
1852. ‡Furguson, Professor John C., M.A., M.B. Queen's College, Belfast.
Furlong, Rev. Thomas, M.A. 10 Sydney-place, Bath.
1864. *Furneaux, Rev. A. St. Germain's Parsonage, Cornwall.

*Gadesden, Augustus William, F.S.A. Leigh House, Lower Tooting, Surrey.
1854. ‡*Gage, M. A., C.E.*
1857. ‡Gages, Alphonse, M.R.I.A. Museum of Irish Industry, Dublin.
1863. *Gainsford, W. D. Darnall Hall, Sheffield.
1850. ‡Gairdner, W. F., M.D. 18 Hill-street, Edinburgh.
1861. ‡Galbraith, Andrew. Glasgow.
Galbraith, Rev. J. A., M.R.I.A. Trinity College, Dublin.
1863. §Gale, Samuel, F.C.S. 338 Oxford-street, London, W.
1861. ‡Galloway, Charles John. Knott Mill Iron Works, Manchester.
1859. ‡*Galloway, James. Calcutta.*
1861. ‡Galloway, John, jun. Knott Mill Iron Works, Manchester.
Galloway, S. H. Linbach, Austria.
1860. *Galton, Captain Douglas, C.B., R.E., F.R.S., F.G.S., F.R.G.S. 12 Chester-street, Grosvenor-place, London, S.W.
1860. *Galton, Francis, F.R.S., F.G.S., F.R.G.S. (*General Secretary.*) 42 Rutland-gate, Knightsbridge, London, S.W.
1842. Gardiner, Lot. Bradford, Yorkshire.
1862. §Garner, Robert, F.L.S. Stoke-upon-Trent.
1865. ‡Garner, Mrs. Robert. Stoke-upon-Trent.
1842. Garnett, Jeremiah. Warren-street, Manchester.
1852. ‡Garret, James R. Holywood, Belfast.
1854. ‡Garston, Edgar. Aigburth, Liverpool.
1847. *Gaskell, Samuel. 19 Whitehall-place, London, S.W.
1842. Gaskell, Rev. William, M.A. Plymouth-grove, Manchester.
1846. §Gassiot, John Peter, F.C.S., F.R.S. Clapham Common, London, S.
1862. *Gatty, Charles Henry, M.A., F.L.S., F.G.S. Felbridge Park, East Grinsted, Sussex.
1859. ‡Geddes, William D., Professor of Greek, King's College, Old Aberdeen.
1854. ‡Gee, Robert, M.D. Oxford-street, Liverpool.
1855. ‡Gemmell, Andrew. 38 Queen-street, Glasgow.
1855. ‡*Gemmell, Thomas.* 12 *Elmbank-crescent, Glasgow.*
1854. §Gerard, Henry. 13 Rumford-place, Liverpool.
1856. *Gething, George Barkley. Springfield, Newport, Monmouthshire.
Gibb, Duncan. Strand-street, Liverpool.
1863. *Gibb, Sir George Duncan, Bart., M.D., M.A., LL.D., F.G.S. 1 Bryanston street, Portman-square, London; and Falkland, Fife.
*Gibbins, Joseph. Birmingham.*
*Gibbins, Thomas. Birmingham.*
1865. ‡Gibbins, William. Battery Works, Digbeth, Birmingham.
*Gibson, Edward. Hull.*
*Gibson, George Stacey. Saffron Walden.

Year of Election.

1852. ‡*Gibson, James.*
1859. ‡Gibson, William Sidney, M.A., F.S.A., F.G.S. Tynemouth.
1849. ‡Gifford, Rev. E. H. Birmingham.
1842. Gilbert, Dr. Joseph Henry, F.R.S., F.C.S. Harpenden, near St. Albans.
1861. *Gilbert, James Montgomery. Bowdon, Cheshire.
1857. ‡Gilbert, J. T., M.R.I.A. Blackrock, Dublin.
1859. *Gilchrist, James, M.D. Crichton Royal Institution, Dumfries.
Gilderdale, Rev. John, M.A. Walthamstow, Essex.
Giles, Rev. William. Netherleigh House, near Chester.
1864. §Gill, Thomas. (*Local Treasurer.*) 4 Sydney-place, Bath.
1850. ‡Gillespie, Alexander, M.D. Edinburgh.
1854. ‡*Gillis, F. L.*
1849. ‡Gilpin, Benjamin. Newcastle-on-Tyne.
1861. *Gilroy, George. Hindley House, Wigan.
1850. *Gladstone, George, F.C.S. Clapham Common, London, S.
1849. *Gladstone, John Hall, Ph.D., F.R.S., F.C.S. 17 Pembridge-square, Hyde Park, London, W.
1861. *Gladstone, Murray. Broughton, Manchester.
1852. ‡*Gladstone, Thomas Murray.*
1861. *Glaisher, James, F.R.S., F.R.A.S. 1 Dartmouth-place, Blackheath, Kent.
1853. ‡Gleadon, Thomas Ward. Moira-buildings, Hull.
1859. ‡Glennie, J. S. Stuart. 6 Stone-buildings, Lincoln's Inn, London.
Glover, George. Ranelagh-road, Pimlico, London.
1852. ‡Godwin, John. Wood House, Rostrevor, Belfast.
1846. ‡Godwin-Austen, Robert A.C., B.A., F.R.S., F.G.S. Chilworth Manor, Guildford.
Goldsmid, Sir Francis Henry, Bart., M.P. St. John's Lodge, Regent's Park, London, N.W.
1842. *Gooch, Thomas L.*
1857. ‡Good, John. 50 City Quay, Dublin.
1852. ‡Goodbody, Jonathan. Clare, King's County, Ireland.
1842. *Goodman, John, M.D. The Promenade, Southport.
1865. ‡Goodman, J. D. Minories, Birminham.
Goodwin, Very Rev. Harvey, D.D., F.C.P.S., Dean of Ely. Caius College, Cambridge.
1859. ‡*Gordon, H. G.*
*Gordon, Rev. James Crawford, M.A. Delamont, Downpatrick, Downshire.
1857. ‡Gordon, Samuel, M.D. 11 Hume-street, Dublin.
1865. ‡Gore, George, F.R.S. 50 Islington-row, Edgbaston, Birmingham.
*Gotch, Rev. Frederick William, LL.D. Stokes Croft, Bristol.
*Gotch, Thomas Henry. Kettering.
1849. ‡Gough, The Hon. Frederick. Perry Hall, Birmingham.
1857. ‡Gough, The Hon. G. S. Rathronan House, Clonmel.
Gould, John, F.R.S., F.L.S., F.R.G.S., F.Z.S. 26 Charlotte-street, Bedford-square, London, W.C.
1854. ‡*Gourley, Daniel De la C., M.D.*
Gowland, James. London-wall, London, E.C.
1861. ‡Grafton, Frederick W. Park-road, Whalley Range, Manchester.
1848. ‡*Graham, John B.*
Graham, Lieutenant David. Mecklewood, Stirlingshire.
*Graham, Thomas, M.A., D.C.L., F.R.S. L. & E., F.G.S., V.P.C.S., Master of the Mint. 4 Gordon-square, London, W.C.
1852. *Grainger, John. Rose Villa, Belfast.
Grainger, Richard. Newcastle-upon-Tyne.
1850. ‡*Grainger, Thomas.*

Year of Election.

1859. ‡Grant, Hon. James. Cluny Cottage, Forres.
1855. §Grant, Robert, M.A., F.R.A.S., Regius Professor of Astronomy in the University of Glasgow. The Observatory, Glasgow.
1854. ‡*Grantham, John, C.E.*
1864. ‡Grantham, Richard F. 7 Great Scotland-yard, London, S.W.
1854. ‡Grantham, R. B. 7 Great Scotland-yard, London.
Granville, Augustus Bozzi, M.D., F.R.S., F.G.S., M.R.I.A. 5 Cornwall-terrace, Warwick-square, Pimlico, London, S.W.
1854. ‡Gravatt, William, F.R.S. 16 Park-street, Westminster.
*Graves, Rev. Richard Hastings, D.D. Brigown Glebe, Michelstown, Co. Cork.
1864. *Gray, Rev. Charles. Trinity College, Cambridge.
1865. ‡Gray, Charles. Swan-bank, Bilston.
1857. ‡Gray, Sir John, M.D. Rathgar, Dublin.
*Gray, John. Greenock.
*Gray, John Edward, Ph.D., F.R.S., Keeper of the Zoological Collections of the British Museum. British Museum.
1864. ‡Gray, Jonathan. Summerhill-house, Bath.
1859. ‡Gray, Rev. J. H. Bolsover Castle, Derbyshire.
*Gray, William, F.G.S. (*Local Treasurer.*) Minster Yard, York.
1861. *Gray, W., M.P. Darcey Lever Hall, Bolton.
1854. *Grazebrook, Henry, jun. Clent Grove, near Stourbidge, Worcestershire.
1866. §Greaves, Charles A. 13 Wardwicke, Derby.
Green, Rev. Henry, M.A. Heathfield, Knutsford, Cheshire.
*Greenaway, Edward. 16 Lansdowne-crescent, Notting-hill, London.
1858. *Greenhalgh, Thomas. Astley House, Sharples, near Bolton-le-Moors.
1863. ‡Greenwell, G. E. Poynton, Cheshire.
1862. §Greenwood, Henry. Huyton Park, Huxton, near Liverpool.
1849. ‡Greenwood, William. Stones, Todmorden.
1861. *Greg, Robert Philips, F.G.S. (*Local Treasurer.*) Outwood Lodge, near Manchester.
Gregg, T. H. 22 Ironmonger-lane, Cheapside.
1860. ‡Gregor, Rev. Walter, M.A. Pitsligo, Rosehearty, Aberdeenshire.
1861. §Gregson, Samuel Leigh. Aigburth, near Liverpool.
Gresham, Thomas M. Raheny, Dublin.
*Greswell, Rev. Richard, B.D., F.R.S., F.R.G.S. St. Giles's-street, Oxford.
Greville, R. K., LL.D., F.R.S.E. Edinburgh.
Grey, Captain The Hon. Frederick William. Howick, Northumberland.
1866. §Grey, Rev. W. H. C. Nottingham.
1863. ‡Grey, W. S. Norton, Stockton-on-Tees.
1859. ‡Grierson, Thomas Boyle. Thornhill, Dumfriesshire.
1855. ‡*Griffin, Charles.*
*Griffin, John Joseph, F.C.S. Garrick-street, London, W.C.
*Griffin, S. F.*
Griffith, Rev. C. T., D.D. Elm, near Frome, Somerset.
1859. *Griffith, George, M.A., F.C.S. (*Assistant General Secretary.*) 1 Woodside, Harrow.
Griffith, George R. Fitzwilliam-place, Dublin.
*Griffith, Sir Richard, Bart., LL.D., F.R.S.E., M.R.I.A., F.G.S. 2 Fitzwilliam-place, Dublin.
1847. ‡Griffith, Thomas. Bradford-street, Birmingham.
*Griffith, Walter H., M.A. Dublin.*
Griffiths, Rev. John, M.A. 63 St. Giles's, Oxford.
1842. Grimshaw, Samuel, M.A. Errwod, Buxton.
1864. §Groom-Napier, Charles Ottley. Southwell Cottage, Kingsdown, Bristol.

Year of Election.

Grove, William Robert, Q.C., M.A., Ph.D., (PRESIDENT), F.R.S. 46 Upper Harley-street, W; and 4 Hare-court, Temple, London.
1849. †*Grover, Rev. H. M.*
1863. §Groves, Thomas B. 80 St. Mary's-street, Weymouth, Dorset.
1857. †Grubb, Thomas, F.R.S., M.R.I.A. Bank of Ireland, Dublin.
Guest, Edwin, LL.D., M.A., F.R.S., F.L.S., F.R.A.S., Master of Caius College, Cambridge. Caius Lodge, Cambridge; and Sandford-park, Oxfordshire.
Guinness, Henry. 17 College Green, Dublin.
1842. Guinness, Richard Seymour. 17 College Green, Dublin.
1856. *Guise, Sir William Vernon, Bart., F.G.S., F.L.S. Elmore-court, near Gloucester.
1862. †Gunn, Rev. John, M.A. Irstedd Rectory, Norwich.
1866. §Günther, Albert, M.D., F.R.S. British Museum, London, W.C.
1860. *Gurney, Samuel, M.P., F.R.G.S. 20 Hanover-square, London, W.
*Gutch, John James. 88 Micklegate, York.
1850. †*Guthrie, Frederick.*
1864. §Guyon, George. South Cliff Cottage, Ventnor, Isle of Wight.
1857. †Gwynne, Rev. John. St. Columba's College, Dublin.

Hackett, Michael. Brooklawn, Chapelizod, Dublin.
1865. §Hackney, William. 3 Great George-street, Westminster.
Hackworth, Timothy. Darlington.
1865. §Haden, W. H. Cawney Bank Cottage, Dudley.
1866. *Haddon, Frederick. The Park, Nottingham.
1862. †Haddon, Frederick William, Assistant-Secretary to the Statistical Society of London. 12 St. James's-square, London, S.W.
1866. §Haddon, Henry. Lenton Field, Nottingham.
Haden, G. N. Trowbridge, Wiltshire.
1842. Hadfield, George, M.P. Victoria-park, Manchester.
1848. †Hadland, William Jenkins. Banbury, Oxfordshire.
*Hailstone, Edward, F.S.A. Horton Hall, Bradford, Yorkshire.
Halifax, The Right Hon. Viscount. 10 Belgrave-square, London, S.W.; and Hickleston Hall, Doncaster.
1845. †Hall, Elias. Castleton, Derbyshire.
1854. *Hall, Hugh Fergus. 17 Dale-street, Liverpool.
1859. †Hall, John Frederic. Ellerker House, Richmond, Surrey.
Hall, John R. Sutton, Surrey.
1863. †Hall, Thomas Y. Eldon-square, Newcastle-on-Tyne.
*Hall, T. B. Coggeshall, Essex.
1866. §Hall, Rev. Townshend M. Pilton Vicarage, Barnstaple.
1860. §Hall, Walter. 10 Pier-road, Erith.
Halliday, A. H., M.A., F.L.S., M.R.I.A. Carnmoney, Antrim, Ireland.
1861. †Halliday, James. Whalley Court, Whalley Range, Manchester.
1857. †Halpin, George, C.E. Rathgar, near Dublin.
Halsall, Edward. Bristol.
*Halswell, Edmund S., M.A.*
1858. *Hambly, Charles Hambly Burbridge, F.G.S. 96 London-road, Leicester.
1846. †*Hambrough, A. J.*
1866. §Hamilton, Archibald. Southborough, Bromley, Kent.
1857. †Hamilton, Charles W. 40 Dominick-street, Dublin.
1865. §Hamilton, Gilbert. Leicester House, Leamington.
Hamilton, The Very Rev. Henry Parr, Dean of Salisbury, M.A., F.R.S. L. & E., F.G.S., F.R.A.S. Salisbury.
1840. *Hamilton, Mathie, M.D. 22 Warwick-street, Glasgow.
1864. †Hamilton, Rev. S. R., M.A. Hinton Lodge, Bournemouth.
1851. †Hammond, C. C. Lower Brook-street, Ipswich.

Year of Election.

1863. ‡Hancock, Albany, F.L.S. 4 St. Mary's-terrace, Newcastle-upon-Tyne.
1852. ‡*Hancock, Charles Brownlow.*
1863. ‡Hancock, John. 4 St. Mary's-terrace, Newcastle-on-Tyne.
1850. ‡Hancock, John. Manor House, Lurgan, Co. Armagh.
1861. ‡Hancock, Walker. 10 Upper Chadwell-street, Pentonville, London.
1857. ‡Hancock, William J. 74 Lower Gardiner-street, Dublin.
1847. ‡Hancock, W. Nelson, LL.D. 74 Lower Gardiner-street, Dublin.
1865. ‡Hands, M. Coventry.
Handyside, P. D., M.D., F.R.S.E. 11 Hope-street, Edinburgh.
1859. ‡Hannay, John. Montcoffer House, Aberdeen.
1853. ‡Hansell, Thomas T. 2 Charlotte-street, Sculcoates, Hull.
*Harcourt, A. Vernon, M.A., F.C.S. Christ Church, Oxford.
Harcourt, Rev. C. G. Vernon, M.A. Rothbury, Northumberland.
Harcourt, Egerton V. Vernon, M.A., F.G.S. Whitwell Hall, Yorkshire.
*Harcourt, Rev. William V. Vernon, M.A., F.R.S., F.G.S., Hon. M.R.I.A. Nuneham Park, Oxford.
1849. ‡Harding, Charles. Tamworth.
1865. ‡Harding, Charles. Harborne Heath, Birmingham.
1864. §Hardwicke, Robert, F.L.S. 192 Piccadilly, London, W.
1858. *Hardy, Charles. Odsall House, Bradford, Yorkshire.
*Hare, Charles John, M.D., Professor of Clinical Medicine in University College, London. 41 Brook-street, Grosvenor-square, London, S.W.
Hare, Samuel. 9 Langham-place, London, W.
Harford, Summers. Reform Club, London, S.W.
1858. ‡Hargrave, James. Burley, near Leeds.
1853. §Harkness, Robert, F.R.S. L. & E., F.G.S., Professor of Geology in Queen's College, Cork.
Harkworth, Timothy. Soho Shilden, Darlington.
1862. *Harley, George, M.D., F.C.S., Professor of Practical Physiology and Histology in University College, London, W.C.
*Harley, John. Ross Hall, near Shrewsbury.
1862. *Harley, Rev. Robert, F.R.S., F.R.A.S., Professor of Mathematics and Logic in Airedale College, Bradford. The Manse, Brighouse, Yorkshire.
1861. ‡Harman, H. W., C.E. 16 Booth-street, Manchester.
*Harris, Alfred. Ryshwall Hall, near Bingley, Yorkshire.
*Harris, Alfred, jun. Bradford, Yorkshire.
1863. ‡Harris, Charles. 6 Somerset-terrace, Newcastle-on-Tyne.
Harris, The Hon. and Rev. Charles, F.G.S. Bremhill, Chippenham, Wiltshire.
1842. **Harris, George William.*
*Harris, Henry. Heaton Hall, near Bradford.
1845. ‡Harris, Henry H. Cambridge.
1863. ‡Harris, T. W. Grange, Middlesborough-on-Tees.
1862. ‡Harris, William Harry, F.C.S. 33 Gold-street, Northampton.
1860. ‡Harrison, Rev. Francis, M.A. Oriel College, Oxford.
1864. §Harrison, George. Barnsley.
1858. *Harrison, James Park, M.A. Garlands, Ewhurst, Surrey.
1853. ‡Harrison, Robert. 36 George-street, Hull.
1863. ‡Harrison, T. E. Engineers' Office, Central Station, Newcastle-on-Tyne.
1853. *Harrison, William, F.S.A., F.G.S. Galligreaves Hall, near Blackburn, Lancashire.
1849. ‡Harrowby, The Earl of, K.G., D.C.L., F.R.S., F.R.G.S. 39 Grosvenor-square, London, S.W.; and Sandon Hall, Lichfield.

Year of Election.

1859. *Hart, Charles. 54 Wych-street, Strand, London, W.C.
1861. *Harter, J. Collier. Chapel Walks, Manchester.
1842. *Harter, William. Hope Hall, Manchester.
1856. ‡Hartland, F. Dixon, F.S.A., F.R.G.S. The Oaklands, near Cheltenham.
Hartley, James. Sunderland.
Hartley, J. B. Bootle, near Liverpool.
*Hartnell, Auron.*
*Hartnell, M. A., B.A.*
1854. §Hartnup, John, F.R.A.S. Liverpool Observatory, Bidston, Birkenhead.
1850. ‡Harvey, Alexander. 4 South Wellington-place, Glasgow.
*Harvey, Joseph Charles. Cork.
Harvey, J. R., M.D. St. Patrick's-place, Cork.
1862. *Harwood, John, jun. Mayfield, Bolton-le-moors.
1855. ‡Hassall, Arthur Hill. 8 Bennett-street, St. James's, London, S.W.
Hastings, Rev. H. S. Martley Rectory, Worcester.
1842. *Hatton, James. Richmond House, Higher Broughton, Manchester.
1863. §Hatton, James W. Old Lodge, Old Trafford, Manchester.
Haughton, James, M.R.D.S. 34 Eccles-street, Dublin.
1857. ‡Haughton, Rev. Samuel, M.D., M.A., F.R.S., M.R.I.A., F.G.S., Professor of Geology in the University of Dublin. Trinity College, Dublin.
1857. ‡Haughton, S. Wilfred. Grand Canal-street, Dublin.
*Haughton, William. 28 City Quay, Dublin.
1856. ‡*Haville, Henry.*
1847. ‡Hawkins, Rev. Edward, D.D., Provost of Oriel College, Oxford.
Hawkins, John Heywood, M.A., F.R.S., F.G.S. Bignor Park, Petworth, Sussex.
*Hawkins, John Isaac, C.E.*
**Hawkins, Thomas, F.G.S.*
1851. ‡*Hawkins, W. W.*
*Hawkshaw, John, F.R.S., F.G.S. 43 Eaton-place, London, S.W.
1864. *Hawkshaw, John Clark, B.A., F.G.S. 43 Eaton-place, London.
1853. ‡Haworth, Benjamin, J.P. Hull Bank House, near Hull.
*Hawthorn, Robert, C.E. Newcastle-upon-Tyne.
1863. ‡Hawthorn, William. The Cottage, Benwell, Newcastle-upon-Tyne.
1859. ‡Hay, Sir Andrew Leith, Bart. Rannes, Aberdeenshire.
1861. *Hay, Sir John D. United Service Club, London, S.W.
1858. ‡Hay, Samuel. Albion-place, Leeds.
1857. ‡Hayden, Thomas, M.D. 30 Harcourt-street, Dublin.
1856. ‡Hayward, J. Curtis. Quedgeley, near Gloucester.
1858. *Hayward, Robert Baldwin, M.A. Harrow-on-the-hill.
1851. ‡Head, Jeremiah. Woodbridge-road, Ipswich.
1861. *Heald, James. Parr's Wood, Didsbury, near Manchester.
1863. ‡Heald, Joseph. 22 Leazes-terrace, Newcastle-on-Tyne.
1854. ‡Healey, Elkanah. Gateacre, Liverpool.
1861. *Heape, Benjamin. Northwood, near Manchester.
1865. §Hearder, William. Torquay.
1866. §Heath, Rev. D. J. Esher, Surrey.
1854. ‡*Heath, Edward.*
1863. ‡Heath, G. Y., M.D. Westgate-street, Newcastle-on-Tyne.
Heath, John. 11 Albemarle-street, London, W.
1861. §Heathfield, W. E., F.C.S., F.R.G.S. 20 King-street, St. James's, London, S.W.
1865. §Heaton, Harry. Warstone, Birmingham.
1858. *Heaton, John Deakin, M.D. Claremont, Leeds.
1865. ‡Heaton, Ralph. Harborne Lodge, near Birmingham.

Year of Election.

1863. †Heckels, Richard. Pensher, near Fencehouses, Durham.
1855. †Hector, James, M.D., F.R.S.E., F.G.S., F.R.G.S., Geological Survey of Otago. New Zealand.
1863. †Hedley, Thomas. Cox Lodge, near Newcastle-on-Tyne.
*Heelis, Thomas. Princes-street, Manchester.
1854. †Heldenmaier, B., Ph.D. Worksop, Notts.
1862. †Helm, George F. 58 Trumpington-street, Cambridge.
1857. *Hemans, George William, C.E., M.R.I.A.. 32 Leinster-gardens, Hyde Park, London, W.
1845. †Henderson, Andrew. 120 Gloucester-place, Portman-square, London.
1860. §Henderson, James, jun. Dundee.
1856. †Hennessy, Henry G., F.R.S., M.R.I.A., F.R.G.S. Wynnefield, Rathgar, Co. Dublin.
1857. †Hennessy, John Pope. Inner Temple, London, E.C.
Henry, Franklin. Portland-street, Manchester.
Henry, J. Snowdon. East Dene, Bonchurch, Isle of Wight.
Henry, Mitchell. Stratheden House, Hyde Park, London, W.
*Henry, William Charles, M.D., F.R.S., F.R.G.S. Haffield, near Ledbury, Herefordshire.
Henwood, William Jory, F.R.S., F.G.S. 3 Clarence-place, Penzance.
1855. *Hepburn, J. Gotch. Clapham Common, Surrey, S.
1855. †Hepburn, Robert. Portland-place, London, W.
Hepburn, Thomas. Clapham, London.
Hepworth, John Mason. Ackworth, Yorkshire.
1856. †Hepworth, Rev. Robert. 2 St. James's-square, Cheltenham.
1864. §Herapath, William Bird, M.D., F.R.S. L. & E. Old Market-street, Bristol.
*Herbert, Thomas. Nottingham.
1852. †Herdman, John. 9 Wellington-place, Belfast.
1866. §Herrick, Perry. Bean Manor Park, Loughborough.
Herschel, Sir John Frederick William, Bart., K.H., M.A., D.C.L., F.R.S. L. & E., Hon. M.R.I.A., F.G.S., F.R.A.S. Collingwood, near Hawkhurst, Kent.
1861. †Hertz, James. Sedgley-park, Prestwich, near Manchester.
1851. †Hervey, The Rev. Lord Arthur. Ickworth, Suffolk.
1865. †Heslop, Dr. Birmingham.
1863. †Heslop, Joseph. Pilgrim-street, Newcastle-on-Tyne.
1832. †Hewitson, William C. Oatlands, Surrey.
Hey, Rev. William, M.A., F.C.P.S. Clifton, York.
1866. *Heymann, Albert. West Bridgford, Nottinghamshire.
1866. §Heymann, L. West Bridgford, Nottinghamshire.
1861. *Heywood, Arthur Henry. Sedgley-park, Manchester.
*Heywood, James, F.R.S., F.G.S., F.S.A., F.R.G.S. 26 Palace-gardens, Kensington, London, W.
1861. *Heywood, Oliver. Acresfield, Manchester.
*Heywood, Robert. The Pike, Bolton.
Heywood, Thomas Percival. Claremont, Manchester.
1854. †*Heyworth, Captain L., jun.*
1864. *Hiern, W. P., M.A. St. John's College, Cambridge.
1854. *Higgin, Edward. Liverpool.
1861. *Higgin, James. Hopwood-avenue, Manchester.
Higginbotham, Samuel. Exchange-square, Glasgow.
1866. §Higginbottom, John. Nottingham.
1861. †Higgins, George. Mount House, Higher Broughton, Manchester.
1854. †Higgins, Rev. Henry H., M.A. Rainhill, Liverpool.
1861. *Higgins, James. Stocks House, Cheetham, Manchester.
1854. †Highley, Samuel, F.G.S. Boxhill, near Dorking, Surrey.
1842. *Higson, Peter. Irwell-terrace, Lower Broughton, Manchester.

Year of Election.

Hildyard, Rev. James, B.D., F.C.P.S. Ingoldsby, near Grantham, Lincolnshire.
1862. *Hiley, Rev. Simeon. St. John's College, Cambridge.
Hill, Arthur. Bruce Castle, Tottenham, London, N.
*Hill, Rev. Edward, M.A., F.G.S. Sheering Rectory, Harlow.
1857. ‡Hill, John. Tullamore, Ireland.
1855. ‡Hill, Laurence. Port Glasgow.
*Hill, Sir Rowland, K.C.B., D.C.L., F.R.S., F.R.A.S. Hampstead, London, N.W.
1864. ‡Hill, William. Combe Hay, Bristol.
1863. §Hills, F. C. Chemical Works, Deptford, Kent.
1858. ‡Hincks, Rev. Thomas, B.A. Mountside, Leeds.
Hincks, Rev. William, F.L.S., Professor of Natural History in University College. Toronto, Canada West.
Hindley, Rev. H. J. Walton-on-the-hill, Lancashire.
1852. *Hindmarsh, Frederick, F.G.S., F.R.G.S. 17 Bucklersbury, London.
*Hindmarsh, Luke. Alnwick.
1865. §Hinds, James, M.D. Queen's College, Birmingham.
1863. §Hinds, William, M.D. Parade, Birmingham.
1861. *Hinmers, William. Farnworth, Bolton.
1858. §Hirst, John, jun. Dobcross, near Manchester.
1861. *Hirst, T. Archer, Ph.D., F.R.S., F.R.A.S. (*General Secretary*), Professor of Mathematics in University College, London. The Athenæum Club; and 14 Waverley-place, St. John's-wood, London, N.W.
1856. ‡Hitch, Samuel, M.D. Sandywell Park, Gloucestershire.
1860. ‡Hitchman, John. Leamington.
*Hoare, Rev. George Tooker. Tandridge, Godstone.
Hoare, J. Gurney. Hampstead, London.
1864. ‡Hobhouse, Arthur Fane. 24 Cadogan-place, Sloane-street, London.
864. ‡Hobhouse, Charles Parry. 24 Cadogan-place, Sloane-street, London.
1864. ‡Hobhouse, Henry William. 24 Cadogan-place, Sloane-street, London.
1863. §Hobson, A. S., F.C.S. 3 Upper Heathfield-terrace, Turnham Green, London.
1866. §*Hockin, Charles.*
1852. ‡Hodges, John F., M.D., Professor of Agriculture in Queen's College, Belfast. 23 Queen-street, Belfast.
1863. *Hodgkin, Thomas. (*Local Treasurer.*) Newcastle-on-Tyne.
1847. ‡Hodgkinson, Rev. G. C. The Lodge, Louth.
*Hodgson, Adam. Everton, Liverpool.
Hodgson, Joseph, F.R.S. 60 Westbourne-terrace, London, W.
1863. ‡Hodgson, Robert. Whitburn, Sunderland.
1863. ‡Hodgson, R. W. North Dene, Gateshead.
Hodgson, Thomas. Market-street, York.
1860. ‡*Hogan, Rev. A. R., M.A.*
1865. §Hofmann, Augustus William, F.R.S., F.C.S. Chemical Laboratory of the University of Berlin.
Hogan, William, M.A., M.R.I.A. Haddington-terrace, Kingstown, near Dublin.
Hogg, John, M.A., F.R.S., F.L.S., F.R.G.S., F.C.P.S. 8 Serjeants' Inn, London, E.C.; and Norton, Stockton-on-Tees.
1861. ‡Holcroft, George, C.E. Red Lion-court, St. Ann's-square, Manchester.
1854. *Holcroft, George. 82 Great Ducie-street, Strangeways, Manchester.
*Holditch, Rev. Hamnet, M.A. Caius College, Cambridge.
1856. ‡Holland, Henry, M.P. Dumbleton, Evesham.
1858. ‡Holland, Loton. Swanscoe Park, Macclesfield.
1865. ‡Holliday, William. New Street, Birmingham.

Year of Election.

*Hollingsworth, John. London-street, Greenwich, Kent, S.E.
1866. *Holmes, Charles. London-road, Derby.
*Holmes, Rev. W. R.*
Hone, Joseph, M.R.D.S. 2 Harcourt-street, Dublin.
1851. †*Honywood, Robert.*
1858. †Hook, The Very Rev. W. F., D.D., Dean of Chichester. Chichester.
1847. †Hooker, Joseph D., M.D., D.C.L., F.R.S., V.P.L.S., F.G.S. Royal Gardens, Kew.
1865. *Hooper, John P. Fremerton House, Balham, London, S.
1861. §Hooper, William. 7 Pall Mall East, London, S.W.
1856. †Hooton, Jonathan. 80 Great Ducie-street, Manchester.
1842. Hope, Thomas Arthur. Liverpool.
Hope, William. Wavertree, Liverpool.
1865. §Hopkins, J. S. Highfield, Edgbaston, Birmingham.
1858. †Hopkinson, Joseph, jun. Britannia Works, Huddersfield.
Hornby, Hugh. Sandown, Liverpool.
1864. *Horner, Rev. J. J. H. Mells Rectory, Frome.
1858. *Horsfall, Abraham. Leeds.
Horsfall, Charles. Everton, Liverpool.
Horsfall, John. Wakefield.
1854. †Horsfall, Thomas B., M.P. Liverpool.
1855. *Horsfield, George. Brampton-grove, Smedley-lane, Cheetham, Manchester.
1856. †Horsley, John H. 389 High-street, Cheltenham.
Hotham, Rev. Charles, M.A., F.L.S. Roos Patrington, Yorkshire.
1859. §Hough, Joseph. Wrottesley, near Wolverhampton.
Houghton, The Right Hon. Lord, D.C.L. 16 Upper Brook-street, London, W.
Houghton, James. Rodney-street, Liverpool.
1842. *Houldsworth, Henry. Newton-street, Manchester.
1858. †Hounsfield, James. Hemsworth, Pontefract.
1842. *Houtson, John.*
Hovenden, W. F., M.A. Bath.
1859. †Howard, Captain John Henry, R.N. The Deanery, Lichfield.
1863. †Howard, Philip Henry. Corby Castle, Carlisle.
1857. †Howell, Henry H. Museum of Practical Geology, Jermyn-street, London.
1865. *Howlett, Rev. Frederick, F.R.S. St. Augustine's, Hurst-green, Sussex.
1863. §Howorth, H. H. Castleton Hall, Rochdale.
1863. †Howse, R. South Shields.
1854. †Howson, Rev. J. S. South-hill, Toxteth Park, Liverpool.
1835. *Hudson, Henry, M.D., M.R.I.A. Glenville, Fermoy, Co. Cork.
Hudson, John. Oxford.
1842. §Hudson, Robert, F.R.S., F.G.S., F.L.S. Clapham Common, London.
1858. †Huggins, William, F.R.A.S. Upper Tulse-hill, London, S.
1857. §Huggon, William. 30 Park-row, Leeds.
Hughes, D. Abraham. 9 Grays Inn-square, London, W.C.
*Hughes, Frederick Robert.*
1863. †Hughes, T. W. 4 Hawthorn-terrace, Newcastle-on-Tyne.
1865. †Hughes, W. R., F.L.S. General Hospital, Birmingham.
Hull, Arthur H. Brighton.
**Hull, William Darley, F.G.S.*
*Hulse, Sir Edward, D.C.L. 4 New Burlington-street, London; and Breamore House, Salisbury.
1861. †Hume, Rev. A., D.C.L., F.S.A. Everton, Liverpool.
1845. †Humpage, Edward. Bristol.
1856. †*Humphreys, E. R., LL.D.*

Year of Election.

1856. †Humphries, David James. 1 Keynsham-parade, Cheltenham.
1862. *Humphry, George Murray, M.D., F.R.S. Trumpington-street, Cambridge.
1863. *Hunt, Augustus H., Ph.D. Pelaw Main Office, Newcastle-on-Tyne.
1860. †Hunt, James, Ph.D., F.S.A. Ore House, near Hastings.
1865. §Hunt, J. P. Gospel Oak Works, Tipton.
1840. §Hunt, Robert, F.R.S., Keeper of the Mining Records. Museum of Practical Geology, Jermyn-street, London, S.W.
1864. §Hunt, W. 72 Pulteney-street, Bath.
Hunter, Adam, M.D., F.R.S.E. Edinburgh.
Hunter, Andrew G. Low Walker, Newcastle-on-Tyne.
Hunter, Robert, F.R.S., F.G.S., F.R.A.S., F.S.A. Southwood-lane, Highgate, London.
1859. †*Hunter, Dr. Thomas, Deputy Inspector-General of Army Hospitals.*
1855. *Hunter, Thomas C. Greenock.
1863. †Huntsman, Benjaman. West Retford Hall, Retford.
1861. *Hurst, William John. 2A Victoria-street, Manchester.
1851. †*Hurwood, George.*
Husband, William Dalla. Coney-street, York.
*Hutchinson, John. Widnes Dock, Warrington.
1863. †Hutt, The Right Hon. W., M.P. Gibside, Gateshead.
Hutton, Crompton. Putney-park, Surrey, S.W.
Hutton, Daniel. 4 Lower Dominick-street, Dublin.
1864. *Hutton, Darnton. 11 Warnford-court, Throgmorton-street, London, E.C.
Hutton, Henry. Eccles-street, Dublin.
1857. †Hutton, Henry D. 1 Nelson-street, Dublin.
*Hutton, Robert, M.R.I.A., F.G.S. Putney Park, Surrey.
1861. §Hutton, T. Maxwell. Summerhill, Dublin.
1852. †Huxley, Thomas Henry, Ph.D., F.R.S., F.L.S., F.G.S., Professor of Natural History in the Government School of Mines, and Hunterian Professor of Comparative Anatomy in the Royal College London. 26 Abbey Place, St. John's Wood, London.
1846. †Huxtable, Rev. Anthony. Sutton Waldron, near Blandford.
Hyde, Edward. Dukinfield, near Manchester.
Hyett, William Henry, F.R.S. Painswick, near Stroud, Gloucestershire.
1847. †Hyndman, George C. 5 Howard-street, Belfast.

*Ibbetson, Captain L. L. Boscawen, Chevalier Red Eagle of Prussia *with Swords*, Chevalier de Hohenzollern, F.R.S., F.G.S.
1854. †*Ihne, William, Ph.D.*
1861. ‡Iles, Rev. J. H. Rectory, Wolverhampton.
1858. ‡Ingham, Henry. Wortley, near Leeds.
1858. †Ingram, Hugo C. Meynell. Temple Newsam, near Leeds.
1858. *Ingram, Hugo Francis Meynell. Temple Newsam, Leeds.
1852. †Ingram, J. K., LL.D., M.R.I.A., Regius Professor of Greek. Trinity College, Dublin.
1854. *Inman, Thomas, M.D. Rodney-street, Liverpool.
1856. †*Invararity, J. D. Bombay.*
Ireland, R. S., M.D. 121 Stephen's Green, Dublin.
1857. †Irvine, Hans, M.A., M.B. 1 Rutland-square, Dublin.
Irwin, Rev. Alexander, M.A. Armagh, Ireland.
1845. †Irwin, Thomas. Somerset House, London, W.C.
1862. §Iselin, J. F., M.A. Wimbledon, Surrey.
1863. *Ivory, Thomas. 9 Ainslie-place, Edinburgh.
1865. †Jabet, George. Wellington-road, Handsworth, Birmingham.

Year of Election.

1859. §Jack, John. Belhelvie by Whitecairns, Aberdeenshire.
1863. *Jackson, Mrs. H. 24 Hereford-square, Gloucester-road, Old Brompton, London.
1865. †*Jackson, Edwin.*
1858. †*Jackson, Edwin W.*
1866. §Jackson, H. W. Springfield, Tooting, Surrey.
Jackson, Professor Thomas, LL.D. St. Andrew's, Scotland.
1855. †*Jackson, Rev. William, M.A. St. John's, Workington.*
Jacob, Arthur, M.D. 23 Ely-place, Dublin.
1852. †Jacobs, Bethel. 40 George-street, Hull.
1865. *Jaffray, John. 'Journal' Office, New-street, Birmingham.
1859. †James, Edward. 9 Gascoyne-terrace, Plymouth.
1860. †James, Edward H. 9 Gascoyne-terrace, Plymouth.
James, Colonel Sir Henry, R.E., F.R.S., F.G.S., M.R.I.A. Ordnance Survey Office, Southampton.
James, Sir John K., Bart., M.R.I.A. 9 Cavendish-row, Dublin.
1863. *James, Sir Walter. 6 Whitehall-gardens, London, S.W.
1858. †James, William C. 9 Gascoyne-terrace, Plymouth.
1863. †Jameson, John Henry. 10 Catherine-terrace, Gateshead.
1859. *Jamieson, Thomas F., F.G.S. Ellon, Aberdeenshire.
1850. †Jardine, Alexander. Jardine Hall, Lockerby.
Jardine, James, C.E., F.R.A.S. Edinburgh.
*Jardine, Sir William, Bart., F.R.S.E. Jardine Hall, Applegarth by Lockerby, Dumfriesshire.
1853. *Jarratt, Rev. John, M.A. North Cave, near Brough, Yorkshire.
Jarrett, Rev. Thomas, M.A., Professor of Arabic in the University of Cambridge. Trunch, Norfolk.
1862. †Jeakes, Rev. James, M.A. Harrow.
Jebb, Rev. John. Peterstow Rectory, Ross, Herefordshire.
1842. *Jee, Alfred S. 2 Oxford-square, Hyde Park, London, W.
1856. †Jeffery, Henry, M.A. 438 High-street, Cheltenham.
1855. *Jeffray, John. 193 St. Vincent-street, Glasgow.
1861. *Jeffreys, J. Gwyn, F.R.S., F.L.S., F.G.S. 25 Devonshire-place, Portland-place, London, W.
1854. †Jeffreys, W. P. Washington-street, Liverpool.
1852. †Jellett, Rev. John H., M.A., M.R.I.A. Professor of Natural Philosophy in Trinity College, Dublin.
1842. Jellicorse, John. Chaseley, near Rugely, Staffordshire.
1864. §Jelly, Dr. W. Paston Hall, near Peterborough.
1862. §Jenkin, Fleeming, F.R.S., Professor of Civil Engineering in University College, London. 6 Duke-street, Adelphi, London, W.C.
1864. §Jenkins, Captain Griffith, C.B., F.R.G.S. Derwin, Welshpool.
*Jenkyns, Rev. Henry, D.D. Durham.
Jennette, Matthew. Birkenhead.
1852. †Jennings, Francis M., F.G.S., M.R.I.A. Brown-street, Cork.
1861. †Jennings, Thomas. Cork.
*Jenyns, Rev. Leonard, M.A., F.L.S., F.G.S. 1 Darlington-place, Bathwick, Bath.
1845. †*Jerdan, William.*
*Jerram, Rev. S. John, M.A. Chobham Vicarage, Bagshot, Surrey.
*Jerrard, George Birch, B.A. Long Stratton, Norfolk.
1845. †Jessop, William, sen. Butterley Hall, Derbyshire.
Jessop, William, jun. Butterley Hall, Derbyshire.
1849. †Jeune, The Right Rev. Francis, D.C.L., Bishop of Peterborough.
Job, Samuel. Holmfield House, Aigburth, Liverpool.
1865. *Johnson, G. J. 34 Waterloo-street, Birmingham.
1866. §Johnson, John. Low Pavement, Nottingham.

Year of Election.

1866. §Johnson, John G. Basinghall-street, London, E.C.
1861. ‡Johnson, Richard. 27 Dale-street, Manchester.
1863. ‡Johnson, R. S. Hanwell, Fence Houses, Durham.
*Johnson, Thomas. The Hermitage, Frodsham, Cheshire.
1864. ‡Johnson, Thomas. 30 Belgrave-street, Commercial-road, London, E.
Johnson, William. The Wynds Point, Colwall, Malvern, Worcestershire.
1861. ‡Johnson, William Beckett. Woodlands Bank, near Altrincham.
1849. ‡Johnston, Alexander Keith, LL.D., F.R.S.E., F.G.S., F.R.G.S. 4 St. Andrew-square, Edinburgh.
Johnston, Alexander Robert, F.R.S. 19 Great Cumberland-place, London; and The Grove, Yoxford, Suffolk.
1859. ‡*Johnston, David, M.D. Montrose.*
1864. ‡Johnston, David. 13 Marlborough-buildings, Bath.
Johnston, Edward. Field House, Chester.
1845. ‡*Johnston, G., M.D.*
1859. ‡Johnston, James. Newmill, Elgin, N. B.
1864. ‡Johnston, James. Manor House, Northend, Hampstead, London, N.
Johnston, Percival Norton, F.R.S., F.G.S. Stoke House, Stoke Fleming, Dartmouth.
*Johnstone, James. Alva, near Alloa, Stirlingshire.
*Johnstone, Sir John Vanden Bempde, Bart., M.P., M.A., F.G.S 27 Grosvenor-square, London; and Harkness.
1864. ‡Johnstone, John. 1 Barnard-villas, Bath.
Jollie, Walter. Edinburgh.
1864. ‡Jolly, Thomas. Park View-villas, Bath.
1849. ‡Jones, Baynham. Selkirk Villa, Cheltenham.
*Jones, Christopher Hird. 2 Castle-street, Liverpool.
1856. ‡Jones, C. W. 7 Grosvenor-place, Cheltenham.
*Jones, Rev. Harry Longueville, Inspector of Schools.*
1858. ‡Jones, Henry Bence, M.A., M.D., F.R.S., Hon. Sec. to the Royal Institution. 31 Brook-street, Grosvenor-square, London, S.W.
1854. ‡Jones, Rev. Henry H. Cemetery, Manchester.
1854. ‡Jones, John. 28 Chapel-street, Liverpool.
1864. ‡Jones, John, F.G.S.
1865. §Jones, John. 40 Union-passage, Birmingham.
*Jones, Josiah. 2 Castle-street, Liverpool.
*Jones, Robert. 2 Castle-street, Liverpool.
1854. *Jones, R. L. Princes Park, Liverpool.
1847. ‡Jones, Thomas Rymer, Professor of Comparative Anatomy in King's College. 18 St. Leonard's-terrace, Clifton-gardens, Maida-hill, London, W.
1860. ‡Jones, T. Rupert, F.G.S., Professor of Geology and Mineralogy, Royal Military College, Sandhurst. 15 College-terrace, York Town, Surrey.
1864. §Jones, Sir Willoughby. Cranmer Hall, Fakenham, Norfolk.
1853. ‡*Jopling, R. Thompson.*
1851. ‡Josselyn, G. Tower-street, Ipswich.
*Joule, Benjamin St. John B. Thorncliffe, Old Trafford, Manchester.
1842. *Joule, James Prescott, LL.D., F.R.S., F.C.S. Thorncliffe, Old Trafford, Manchester.
1848. *Joy, Rev. Charles Ashfield. Grove Parsonage, near Wantage, Berkshire.
Joy, Henry Holmes, M.A., M.R.I.A. 17 Mountjoy-square East, Dublin.
Joy, William B., M.D. 48 Leeson-street, Dublin.
1847. ‡Jowett, Rev. B., M.A. Balliol College, Oxford.
1858. ‡Jowett, John, jun. Leeds.

Year of Election.

*Jubb, Abraham. Halifax.
1863. ‡Jukes, Rev. Andrew. Spring Bank, Hull.
Jukes, Joseph Beete, M.A., F.R.S., F.G.S., M.R.I.A., Local Director of the Government Geological Survey of Ireland. 51 Stephen's Green, Dublin.

Kane, Sir Robert, M.D., F.R.S., M.R.I.A., Principal of the Royal College of Cork. 51 Stephen's Green, Dublin.
1857. ‡Kavanagh, James W. Grenville, Rathgar, Ireland.
1859. ‡Kay, David, F.R.G.S. 6 North-bridge, Edinburgh.
Kay, John Cunliff. Fairfield Hall, near Skipton.
*Kay, John Robinson. Boss Lane House, Bury, Lancashire.
Kay, Robert. Haugh Bank, Bolton-le-Moors.
1847. *Kay, Rev. William, D.D. Lincoln College, Oxford.
1856. ‡Kay-Shuttleworth, Sir James, Bart. Gawthorpe, Burnley.
1855. ‡Kaye, Robert. Mill Brae, Moodies Burn, by Glasgow.
1855. ‡Keddie, William. 15 North-street, Mungo-street, Glasgow.
1866. §Keene, Alfred. Eastmoor House, Leamington.
1850. ‡Kelland, Rev. Philip, M.A., F.R.S.L. & E., Professor of Mathematics in the University of Edinburgh. 20 Clarendon Crescent, Edinburgh.
1849. ‡Kelly, John, C.E. 38 Mount Pleasant-square, Dublin.
1857. ‡Kelly, John J. 38 Mount Pleasant-square, Dublin.
1864. *Kelly, W. M., M.D. 11 The Crescent, Taunton, Somerset.
1842. *Kelsall, Henry. Rochdale, Lancashire.
1842. Kelsall, J. Rochdale, Lancashire.
1864. *Kemble, Rev. Charles, M.A. Vellore, Bath.
1853. ‡Kemp, Rev. Henry William, B.A. Thanet House, Hull.
1858. ‡Kemplay, Christopher. Leeds.
1850. ‡*Kempson, Samuel.*
1854. ‡Kennedy, James. 33 Erskine-street, Liverpool.
1857. ‡Kennedy, Lieut-Colonel John Pitt. 20 Torrington-square, Bloomsbury, London, W.C.
1858. ‡*Kennie, C. G. Colleton.*
Kenny, Matthias, M.D. 3 Clifton-terrace, Monkstown, Co. Dublin.
*Kenrick, Rev. George.*
1865. ‡Kenrick, William. Norfolk-road, Edgbaston, Birmingham.
Kent, J. C. Levant Lodge, Earl's Croome, Worcester.
1857. ‡Kent, William T., M.R.D.S. 51 Rutland-square, Dublin.
1857. ‡Kenworth, James Ryley. 7 Pembroke-place, Liverpool.
1857. *Ker, André Allen Murray. Newbliss House, Newbliss, Ireland.
1855. *Ker, Robert. Auchinraith, Glasgow.
1865. *Kerr, William D., M.D., R.N. Bonnyrigg, Edinburgh.
1861. *Keymer, John. Parker-street, Manchester.
1854. ‡Kilpin, Thomas Johnstone. 1 Arrad-street, Liverpool.
1865. *Kinahan, Edward Hudson. 11 Merrion-square North, Dublin.
1860. ‡Kinahan, G. Henry. Geological Survey of Ireland, 51 Stephen's Green, Dublin.
1858. ‡Kincaid, Henry Ellis, M.A. 8 Lyddon-terrace, Leeds.
1854. ‡King, Alfred. 1 Netherfield-road South, Liverpool.
1855. ‡King, Alfred, jun. Everton, Liverpool.
King, The Hon. James, M.R.I.A. Mitchelstown Castle, Co. Cork.
1855. ‡King, James. Levernholme, Hurlet, Glasgow.
1851. ‡*King, John.*
1851. ‡King, John. Rose-hill, Ipswich.
King, Joseph. Anfield-road, Liverpool.
1864. §King, Kelburne. 27 George Street; and Royal Institution, Hull.
1860. *King, Mervyn Kersteman. 1 Rodney-place, Clifton, Bristol.

Year of Election.

1842. King, Richard, M.D. Savile-row, London, W.
King, Rev. Samuel, M.A., F.R.A.S. St. Aubins, Jersey.
1862. §King, Rev. Samuel William, F.G.S., F.S.A. Saxlingham Rectory, near Norwich.
King, William Poole, F.G.S. Avonside, Clifton, Bristol.
1862. ‡Kingsley, Rev. Charles, M.A., Professor of Modern History in the University of Cambridge. 1 St. Peter's-terrace, Cambridge.
1861. ‡Kingsley, John. 30 St. Ann's-street, Manchester.
1845. ‡Kingsley, Rev. W. T. South Kelvington, Thirsk.
1835. Kingstone, A. John, M.A. Mosstown, Longford, Ireland.
1863. §Kinnaird, The Right Hon. Lord., K.T., F.G.S. Rossie Priory, Inchture, Perthshire.
Kinnear, J. G., F.R.S.E. Glasgow.
1863. ‡Kirkaldy, David. 28 Bartholomew-road North, Kentish Town, London.
1860. ‡Kirkman, Rev. Thomas P., M.A., F.R.S. Croft Rectory, near Warrington.
Kirkpatrick, Rev. W. B. 44 Wellington-street, Dublin.
1850. ‡Kirkwood, Anderson. 151 West George-street, Glasgow.
1849. ‡Kirshaw, John William, F.G.S. Warwick.
1858. ‡Kitson, James. Leeds.
*Knight, Sir A. J., M.D.*
Knipe, A. J. Moorville, Carlisle.
Knowles, George Beauchamp, Professor of Botany in Queen's College, Birmingham. St. Paul's-square, Birmingham.
1842. Knowles, John. Old Trafford Bank House, Old Trafford, Manchester.
*Knowles, William. 2 Clarence-place, Newport, Monmouthshire.
*Knox, G. James. 2 Finchley New-road, St. John's-wood, London.
*Knox, Henry.*
Knox, Rev. H. B., M.A., M.R.I.A. Deanery, Hadleigh, Suffolk.
*Kutz, Andrew.*
1861. *Kyllmann, Max. 28 Brazennose-street, Manchester.
1865. ‡Kynnersley, J. C. S. The Leveretts, Handsworth, Birmingham.

Lace, Ambrose. Liverpool.
1858. §Lace, Francis John. Stone Gapp, Cross-hill, Leeds.
1862. §Lackenstein, Dr. (Care of Messrs. Smith and Elder, Cornhill, London.)
1842. Lacy, Henry C. Withdeane Hall, near Brighton.
1859. §Ladd, William. 11 & 13 Beak-street, Regent-street, London, W.
1850. ‡Laing, David, F.S.A. Scotl. Edinburgh.
Laird, John, M.P. Birkenhead.
1859. §Lalor, John Joseph, M.R.I.A. 2 Longford-terrace, Monkstown, Co. Dublin.
*Lamb, David. Liverpool.*
Lambert, Richard. Newcastle-on-Tyne.
1846. *Laming, Richard. 36 Hamilton-road, Prestonville, Brighton.
1854. §Lamport, William James. Liverpool.
1859. ‡Lang, Rev. John Marshall. Fyvie, Aberdeen.
1864. §Lang, R. Greatwick Hall, Barrow Gurney, near Bristol.
*Langton, William. Manchester.
1840. ‡Lankester, Edwin, M.D., LL.D., F.R.S., F.L.S. 23 Great Marlborough-street, London, W.
1865. §Lankester, E. Ray. Christ Church, Oxford.
*Larcom, Major-General Sir Thomas Aiskew, K.C.B., R.E., F.R.S., M.R.I.A. Phœnix Park, Dublin.
Lassell, William, F.R.S., F.R.A.S. Ray Lodge, Maidenhead.

Year of Election.

1860. ‡Lassell, William, jun. The Brook, near Liverpool.
1861. *Latham, A. G. Cross-street, Manchester.
1845. ‡Latham, Robert G., M.A., M.D., F.R.S., F.R.G.S. New Malden, near Kingston, Surrey.
*La Touche, David Charles, M.R.I.A. Castle-street, Dublin.
1857. ‡Law, Hugh. 4 Great Denmark-street, Dublin.
1862. ‡Law, Rev. James Edmund, M.A. Little Shelford, Cambridgeshire.
*Law, Rev. William, M.A.*
Lawley, The Hon. Francis Charles. Escrick Park, near York.
Lawley, The Hon. Stephen Willoughby. Escrick Park, near York.
1857. ‡Lawson, James A., LL.D., M.R.I.A. 27 Fitzwilliam-street, Dublin.
1855. ‡Lawson, John. Mountain Blue Works, Camlachie.
1858. ‡Lawson, Samuel. Kirkstall, near Leeds.
1863. §Lawton, Benjamin C. Neville Chambers, 44 Westgate-street, Newcastle-upon-Tyne.
1853. ‡Lawton, William. Manor House-street, Hull.
Laycock, Thomas, M.D., Professor of the Practice of Medicine in the University of Edinburgh. 4 Rutland-street, Edinburgh.
1865. §Lea, Henry. 35 Paradise-street, Birmingham.
1857. ‡Leach, Capt. R. E. Mountjoy, Phœnix Park, Dublin.
Leadbetter, John. Glasgow.
1847. *Leatham, Edward Aldam. Whitley Hall, Huddersfield.
1858. ‡Leather, George. Knostrop, near Leeds.
*Leather, John Towlerton. Leventhorpe Hall, near Leeds.
1858. ‡Leather, John W. Newton Green, Leeds.
1863. §Leavers, J. W. The Park, Nottingham.
1858. *Le Cappelain, John. Wood-lane, Highgate, London, N.
1858. ‡Ledgard, William. Potter Newton, near Leeds.
1842. Lee, Daniel. Springfield House, Pendlebury, Manchester.
1861. ‡Lee, Henry. Irwell House, Lower Broughton, Manchester.
Lee, Henry, M.D. Weatheroak, Alvechurch, near Bromsgrove, London.
1853. *Lee, John Edward, F.G.S., F.S.A. The Priory, Caerleon, Monmouthshire.
1845. ‡Lees, Dr. Frederick R. Burmantofts Hall, Leeds.
1850. ‡Lees, George, LL.D. Rillbank, Edinburgh.
1854. ‡Lees, Samuel. Portland-place, Ashton-under-Lyne.
1859. ‡Lees, William. School of Art, Edinburgh.
*Leese, Joseph, jun. Glenfield, Altrincham.
*Leeson, Henry B., M.A., M.D., F.R.S. The Maples, Bonchurch, Isle of Wight.
*Lefroy, John Henry, Brigadier-General R.A., F.R.S., F.R.G.S., President of the Ordnance Select Committee. Grosvenor House, Blackheath, Kent, S.E.
1845. ‡*Legard, Capt. William. India.*
*Legh, George Cornwall, M.P. High Legh, Cheshire.
1856. ‡Leigh, The Right Hon. Lord, D.C.L. 37 Portman-square, London, W.; and Stoneleigh Abbey, Kenilworth.
1861. *Leigh, Henry. The Poplars, Patricroft, near Manchester.
Leigh, John Shaw. Childerall Hall, near Liverpool.
*Leinster, Augustus Frederick, Duke of, M.R.I.A. 6 Carlton House-terrace, London, S.W.
1859. ‡Leith, Alexander. Glenkindie, Inverkindie.
*Lemon, Sir Charles, Bart., F.R.S., F.G.S., F.R.G.S. Carclew, near Falmouth.
1860. ‡Lempriere, Charles, D.C.L. St. John's College, Oxford.
1863. *Lendy, Capt. Auguste Frederic. Practical Military College, Sudbury, Middlesex, S.W.

Year of Election.

1861. †Lennox, A. C. W. 7 Beaufort-gardens, Brompton, London, S.W.
Lentaigne, John, M.D. Tallaght House, Co. Dublin; and 14 Great Dominick-street, Dublin.
Lentaigne, Joseph. 12 Great Denmark-street, Dublin.
1861. †Leppoc, Henry Julius. Kersal Crag, near Manchester.
1852. †Leslie, T. E. Cliffe, LL.B., Professor of Jurisprudence and Political Economy, Queen's College, Belfast.
1859. †Leslie, William, M.P. Warthill, Aberdeenshire.
1846. †Letheby, Henry, M.B., F.L.S., Medical Officer to the City of London. 41 Finsbury-square, London, E.C.
1866. §Levi, Leone, F.S.A., F.S.S., Professor of Commercial Law in King's College, London. 10 Farrar's-building, Temple, London, E.C.
1847. †Ley, Rev. Jacob, M.A. Staverton, near Daventry.
1853. †Liddell, George William Moore. Sutton House, near Hull.
1860. †Liddell, The Very Rev. H. G., D.D., Dean of Christ Church, Oxford.
1855. †Liddell, John. 8 Clelland-street, Glasgow.
1859. †Ligertwood, George. Blair by Summerhill, Aberdeen.
1864. §Lightbody, Robert, F.G.S. Ludlow, Salop.
1862. †Lilford, The Right Hon. Lord, F.L.S. Lilford Hall, Oundle, Northamptonshire.
*Limerick, Charles Graves, D.D., M.R.I.A., Lord Bishop of. Limerick.
*Lindsay, Charles. Glen Osmond, Adelaide, South Australia.
*Lindsay, Henry L., C.E., M.R.I.A. 1 Little Collins-street West, Montreal, Canada.
1855. *Lindsay, John H. 317 Bath-street, Glasgow.
1842. *Lingard, John R., F.G.S. Mayfield, Shortlands, by Bromley, Kent.
*Lingwood, Robert M., M.A., F.L.S., F.G.S.*
Lister, James. Liverpool Union Bank, Liverpool; and Greenbank, Everton.
1858. *Lister, John, F.G.S. Shibden Hall, near Halifax.
*Lister, Joseph Jackson, F.R.S. Upton, Essex.
Littledale, Harold. Liscard Hall, Cheshire.
1854. †Littledale, Thomas. Highfield House, Liverpool.
1861. *Liveing, G. D., M.A., F.C.S., Professor of Chemistry in the University of Cambridge. 12 Hill's-road, Cambridge.
1864. §Livesay, J. G. Ventnor, Isle of Wight.
1860. †Livingstone, Rev. Thomas Gott, Minor Canon of Carlisle Cathedral.
Lloyd, Rev. A. R. Hengold, near Oswestry.
Lloyd, Rev. C., M.A. Whittington, Oswestry.
1848. †Lloyd, Rev. David. Carmarthen.
1842. Lloyd, Edward. King-street, Manchester.
1854. †*Lloyd, F. Geisler.*
1847. **Lloyd, George Whitelocke.*
1865. †Lloyd, G. B. Wellington-road, Ebgbaston, Birmingham.
*Lloyd, George, M.D., F.G.S. Birmingham.
*Lloyd, Rev. Humphrey, D.D., LL.D., F.R.S. L. & E., M.R.I.A., Provost of Trinity College, Dublin.
1865. †Lloyd, John. Queen's College, Birmingham.
Lloyd, Rev. Rees Lewis. Belper, Derbyshire.
1849. †Lloyd, William, M.D. Army and Navy Club, London.
1865. *Lloyd, Wilson. Wood Green, Wednesbury, Wolverhampton.
1854. *Lobley, James Logan, F.G.S. 50 Landsdowne-road, Kensington Park, London.
1853. *Locke, John. Royal Dublin Society, Kildare-street, Dublin.
*Lockey, Rev. Francis. Swainswick, near Bath.
*Lockhart, Alexander M'Donald.*
1863. §Lockyer, J. Norman, F.R.A.S. Victoria-road, Finchley-road, London.
1853. †Loft, John. 17 Albion-street, Hull.

Year of Election.

**Loftus, William Kennett, F.G.S. Calcutta.*
*Logan, Sir William Edmond, LL.D., F.R.S., F.G.S., F.R.G.S., Director of the Geological Survey of Canada. Montreal, Canada.
1862. ‡Long, Andrew, M.A. King's College, Cambridge.
1851. ‡Long, P. B. Museum-street, Ipswich.
1851. ‡Long, William, F.G.S. Hurts Hall, Saxmundham, Suffolk.
1866. §Longdon, F. Derby.
1857. ‡Longfield, Rev. George. 25 Trinity College, Dublin.
Longfield, Mountifort, LL.D., M.R.I.A., Regius Professor of Feudal and English Law in the University of Dublin. 47 Fitzwilliam-square, Dublin.
1861. *Longman, William, F.G.S. 36 Hyde Park-square, London, W.
1859. ‡Longmuir, Rev. John, M.A., LL.D. 14 Silver-street, Aberdeen.
Longridge, W. S. Oakhurst, Ambergate, Derbyshire.
1865. §Longsdon, Robert. Church House, Bromley, Kent.
1861. *Lord, Edward. York-street, Todmorden.
1855. ‡Lorimer, Rev. J. G., D.D. 6 Woodside-place, Glasgow.
1863. ‡Losh, W. S. Wreay Syke, Carlisle.
1834. ‡*Low, Rev. Alexander, F.S.A.*
1863. *Lowe, Arthur S. H. Gosfield Hall, near Nottingham.
1861. *Lowe, Edward Joseph, F.R.S., F.R.A.S., F.L.S., F.G.S. Highfield House Observatory, near Nottingham.
Lowe, George, F.R.S., F.G.S., F.R.A.S. 9 St. John's-wood Park, London, N.W.
1850. ‡Lowe, William Henry, M.D., F.R.S.E. Balgreen, Slateford, Edinburgh.
Lowndes, Matthew D. 49 Edge-lane, near Liverpool.
1853. *Lubbock, Sir John, Bart., F.R.S., F.L.S., F.G.S. High Elms, Farnborough, Kent.
1849. *Luckcock, Howard. Oak-hill, Edgbaston, Birmingham.
1849. ‡Lucy, William. Edgbaston, Birmingham.
1866. *Lund, Charles. Market-street, Bradford.
1850. *Lundie, Cornelius. Rhymney Railway, Cardiff.
1853. ‡Lunn, William Joseph, M.D. 23 Charlotte-street, Hull.
1858. *Lupton, Arthur. Headingley, near Leeds.
1864. *Lupton, D. Leeds.
1866. §Lycett, Francis. 18 Highbury-grove, London, N.
*Lyell, Sir Charles, Bart., M.A., LL.D., D.C.L., F.R.S., F.L.S., V.P.G.S., Hon. M.R.S.Ed. 53 Harley-street, Cavendish-square, London, W.
1864. ‡Lyne, Francis. (Care of Sydney Smith, Esq., Charlotte-row, Mansion House, London, E.C.)
1857. ‡Lyons, Robert D. 31 Upper Merrion-street, Dublin.
1862. *Lyte, Maxwell F., F.C.S. Bagnères de Bigorre, France.
1849. ‡Lyttelton, The Right Hon. Lord, D.C.L. 17 St. James's-place, London, S.W.

1859. ‡Mabson, John. Heyning, Westmoreland.
1852. ‡MacAdam, James, jun. Beavor Hall, Belfast.
1852. ‡MacAdam, Robert. 18 College-square East, Belfast.
1854. *Macadam, Stevenson, Ph.D., F.R.S.E., F.C.S., Lecturer on Chemistry. Surgeons' Hall, Edinburgh.
1852. ‡*Macaldin, J. J., M.D. Coleraine.*
*M'All, Rev. Edward, Rector of Brighstone, Newport, Isle of Wight.
*M'Andrew, Robert, F.R.S. Isleworth House, Isleworth, Middlesex.
1866. *M'Arthur, A. Raleigh Hall, Brixton Rise, London, S.
1855. ‡*M'Arthur, Richard, W. J.*

Year of Election.

1840. Macaulay, Dr. James. 22 Cambridge-road, Kilburne, London, N.W.
1857. ‡*Macauley, James William.*
*MacBrayne, Robert. Messrs. Black and Wingate, 9 Exchange-square, Glasgow.
Macbride, Rev. John David, D.C.L., F.G.S., Principal of Magdalen Hall, and Lord Almoner's Reader in Arabic in the University of Oxford. Oxford.
1866. §M'Callan, Rev. J. F., M.A. St. Matthew's Parsonage, Nottingham.
1855. ‡M'Callum, Archibald K., M.A. House of Refuge, Duke-street, Glasgow.
1863. †M'Calmont, Robert. Gatton Park, Reigate.
1855. ‡M'Cann, James, F.G.S. Holmfrith, Yorkshire.
1857. ‡M'Causland, Dominick. 12 Fitzgibbon-street, Dublin.
M'Clelland, James. 73 Kensington Gardens-square, Bayswater.
1855. ‡M'Clelland, James. 10 Claremont-terrace, Glasgow.
1856. ‡*M'Clelland, John. Calcutta.*
*M'Connel, James. Bent-hill, Prestwich, near Manchester.
1859. **M'Connell, David C., F.G.S.*
1858. ‡M'Connell, J. E. Woodlands, Great Missenden.
1852. ‡M'Cosh, Rev. James, M.A., Professor of Logic, &c., Queen's College, Belfast.
1851. ‡M'Coy, Professor Frederick, F.G.S., Professor of Zoology and Natural History in the University of Melbourne, Australia.
*M'Cullagh, John, A. B.*
*M'Culloch, George, M.D. Cincinnati, United States.
1852. ‡M'Dermott, Edward. Grove Park, The Grove, Camberwell, London.
1850. ‡*Macdonald, Alexander.*
Macdonald, William, M.D., F.R.S.E., F.L.S., F.G.S., Professor of Civil and Natural History. St. Andrews, N. B.
MacDonnell, Hercules H. G. 2 Kildare-place, Dublin.
1864. §MacDonnell, The Very Rev. Canon. 8 Montpellier, Bath.
*M'Ewan, John. Glasgow.
1850. ‡Macfarlan, John Fletcher. Park-place, Edinburgh.
1859. ‡Macfarlane, Alexander. 73 Bon Accord-street, Aberdeen.
1855. ‡M'Farlane, Walter. Saracen Foundry, Glasgow.
1854. *Macfie, R. A. 72 Upper Parliament-street, Liverpool.
1836. ‡M'Gauley, Professor. 147 Richmond-road, Dalston, London, N.E.
1852. *M'Gee, William, M.D. 10 Donegal-square East, Belfast.
1855. ‡MacGeorge, Andrew, jun. 21 St. Vincent-place, Glasgow.
1855. ‡M'Gregor, Alexander Bennett. 19 Woodside-crescent, Glasgow.
1855. ‡MacGregor, James Watt. Wallace-grove, Glasgow.
1850. ‡*M'Gregor, Robert, M.D. Glasgow.*
1853. ‡*M'Gregor, Walter. Liverpool.*
1854. ‡*Macgregor, William.*
1859. ‡M'Hardy, David. 54 Netherkinkgate, Aberdeen.
1854. ‡*M'Ilveen, Alexander Sinclair.*
1855. ‡M'Ilwraith, H. Greenock.
Macintosh, General Alexander Fisher, K.H., F.G.S., F.R.G.S. 7 Tilney-street, Park-lane, London.
1859. ‡Macintosh, John. Middlefield House, Woodside, Aberdeen.
1854. *MacIver, Charles. Abercrombie-square, Liverpool.
1865. ‡*Mackeson, H. B.*
1865. ‡Mackintosh, Daniel, F.G.S. Chichester.
1855. ‡M'Kenzie, Alexander. 89 Buchanan-street, Glasgow.
*Mackenzie, James. Glentore, Scotland.
1850. ‡Mackenzie, J. W. 16 Royal Circus, Edinburgh.
Mackenzie, Rev. Kenneth. The Manse, Borrowstoness, Linlithgowshire.

Year of Election.

1865. §Mackenzie, Kenneth Robert Henderson, F.S.A., F.A.S.L. Seaforth House, Friern Park, near Whetstone, Middlesex.
*Mackerral, William. Paisley.*
1859. ‡Mackie, David. Mitchell-place, Aberdeen.
*Mackinlay, David. Pollokshields, Glasgow.
1850. ‡Maclagan, Douglas, M.D., F.R.S.E. 28 Heriot Row, Edinburgh.
1860. ‡Maclaren, Archibald. Summertown, Oxfordshire.
1864. §MacLaren, Duncan, M.P. Newington House, Edinburgh.
1855. ‡*MacLaren, John.*
1865. *M'Clean, John Robinson. 23 Great George-street, Westminster, London, S.W.
1859. ‡Maclear, Sir Thomas, F.R.S., F.R.G.S., F.R.A.S., Astronomer Royal at the Cape of Good Hope.
1862. ‡Macleod, Henry Dunning. 17 Gloucester-terrace, Camden-hill-road, London, W.
1855. ‡*M'Lintock, William. Lochinch, Pollokshaws, Glasgow.*
1861. *Maclure, John William. 2 Bond-street, Manchester.
1862. ‡Macmillan, Alexander. 1 Trinity-street, Cambridge.
1855. ‡*M'Nab, John. Edinburgh.*
MacNeill, The Right Hon. Sir John, G.C.B., F.R.S.E., F.R.G.S. Granton House, Edinburgh.
MacNeill, Sir John, LL.D., F.R.S., M.R.I.A., Professor of Civil Engineering in Trinity College, Dublin. Mount Pleasant, Dundalk.
1854. ‡M'Nicholl, H., M.D. 42 Oxford-street, Liverpool.
1850. ‡Macnight, Alexander. 12 London-street, Edinburgh.
1859. ‡Macpherson, Rev. W. Kilmuir Easter, Scotland.
Macredie, P. B. Mure, F.R.S.E. Irvine, Ayrshire.
1854. ‡Macrorie, Dr. 126 Duke-street, Liverpool.
1852. *Macrory, Adam John. Duncairn, Belfast.
*Macrory, Edmund. 7 Fig-tree-court, Temple, London, E.C.
1855. ‡M'Tyre, William, M.D. Maybole, Ayrshire.
1855. ‡Macvicar, Rev. John Gibson, D.D. Moffat, near Glasgow.
1857. ‡*Madden, Richard R. Rathmines, Dublin.*
Magor, J. B. Redruth, Cornwall.
1853. ‡Magrath, Rev. Folliot, A.M. Stradbally, Queen's County, Ireland.
1866. §Major, R. H., F.S.A., F.R.G.S. British Museum, London, W.C.
*Malahide, Talbot de, The Right Hon. Lord, F.R.S. Malahide Castle, Malahide, Ireland.
1853. ‡Malan, John. Holmpton, Holderness.
*Malcolm, Frederick. Mordon College, Blackheath, London, S.E.
Malcolm, Neil. Portalloch, Lochgilphead.
1850. ‡Malcolm, R. B., M.D., F.R.S.E. 126 George-street, Edinburgh.
1863. ‡Maling, C. T. Lovaine-crescent, Newcastle-on-Tyne.
*Mallet, Robert, Ph.D., F.R.S., F.G.S., M.R.I.A. 11 Bridge-street, Westminster, London; and The Grove, Clapham-road, Clapham, London, S.
1857. ‡Mallet, Dr. John William. University of Alabama, U. S.
1846. ‡Manby, Charles, F.R.S., F.G.S. 15 Harley-street, London, W.
*Manchester, James Prince Lee, Lord Bishop of, F.R.S., F.G.S., F.R.G.S., F.C.P.S. Mauldreth Hall, Manchester.
1863. ‡*Mancini, Count de, Italian Consul.*
1866. §Mann, Robert James, M.D., F.R.A.S. 12 Cecil-street, Strand, London, W.C.
Manning, The Right Rev. H.
1866. §Manning, John. Waverley-street, Nottingham.
1864. ‡Mansel, J. C. Long Thorns, Blandford.
1865. ‡March, J. F. Fairfield House, Warrington.

Year of Election.

1864. §Markham, Clements R., F.R.G.S. 21 Eccleston-square, Pimlico, London, S.W.
1852. ‡Marland, James William. Mountjoy-place, Dublin.
1863. ‡Marley, John. Mining Office, Darlington.
*Marling, Samuel S. Stanley Park, Stroud, Gloucestershire.
Marriott, John. Allerton, Liverpool.
1857. §Marriott, William. Leeds-road, Huddersfield.
1858. ‡Marriott, William Thomas. Wakefield.
1842. Marsden, Richard. Norfolk-street, Manchester.
1866. §Marsh, Dr. J. C. L. Park-row, Nottingham.
1856. ‡Marsh, M. H. Wilbury Park, Wilts.
1864. §Marsh, Thomas Edward Miller. 37 Grosvenor-place, Bath.
Marshall, James. Headingly, near Leeds.
1852. ‡Marshall, James D. Holywood, Belfast.
*Marshall, James Garth, M.A., F.G.S. Headingly, near Leeds.
1858. ‡Marshall, Reginald Dykes. Adel, near Leeds.
1849. *Marshall, William P. 6 Portland-road, Edgbaston, Birmingham.
1865. §Marten, E. B. 13 High-street, Stourbridge.
Martin, Rev. Francis, M.A. Trinity College, Cambridge.
**Martin, Francis P. Brouncker.*
1848. ‡Martin, Henry D. 4 Imperial Circus, Cheltenham.
Martin, Studley. 107 Bedford-street South, Liverpool.
*Martindale, Nicholas. Peter-lane, Hanover-street, Liverpool.
*Martineau, Rev. James. 10 Gordon-street, Gordon-square, London.
1865. ‡Martineau, R. F. Highfield-road, Edgbaston, Birmingham.
1865. ‡Martineau, Thomas. 7 Cannon-street, Birmingham.
1847. ‡Maskelyne, Nevil Story, M.A., F.G.S. British Museum, London, W.C.
1861. *Mason, Hugh. Ashton-under-Lyne.
*Mason, Thomas. York.
Massey, Hugh, Lord. Hermitage, Castleconnel, Co. Limerick.
*Mather, Daniel. 58 Mount Pleasant, Liverpool.
*Mather, John. 58 Mount Pleasant, Liverpool.
1863. *Mather, Joseph. Beech Grove, Newcastle-on-Tyne.
1865. *Mathews, G. S. Edgbaston House, Hagley-road, Birmingham.
1861. *Mathews, William, jun., M.A., F.G.S. 51 Carpenter-road, Birmingham.
1859. ‡Matthew, Alexander C. 3 Canal-terrace, Aberdeen.
1865. ‡Matthews, C. E. Waterloo-street, Birmingham.
1858. ‡Matthews, F. C. Mandre Works, Driffield, Yorkshire.
*Matthews, Henry, F.C.S. 60 Gower-street, London, W.C.
1860. ‡Matthews, Rev. Richard Brown. The Vicarage, Shalford, near Guildford.
1863. *Matthiessen, Augustus, Ph.D., F.R.S., Lecturer on Chemistry, St. Mary's Hospital. Paddington, London, W.
1857. ‡*Maughan, Rev. J. D.*
1863. ‡Maughan, Rev. W. Benwell Parsonage, Newcastle-on-Tyne.
1855. ‡Maule, Rev. Thomas, M.A. Partick, near Glasgow.
1865. *Maw, George, F.L.S., F.G.S., F.S.A. Benthall Hall, Broseley, Salop.
1863. *Mawson, John. 3 Moseley-street, Newcastle-on-Tyne.
1864. *Maxwell, Francis. Gribton, near Dumfries.
*Maxwell, James Clerk, M.A., F.R.S., L. & E., Professor of Natural Philosophy and Astronomy in King's College, London. 8 Palace Garden-terrace, Kensington, London, W.
1855. *Maxwell, Sir John, Bart., F.R.S. Pollok House, Renfrewshire.
1852. ‡Maxwell, John Waring. Finnebrogue, Downpatrick, Ireland.
*Maxwell, Robert Percival. Finnebrogue, Downpatrick, Ireland.
1865. *May, Walter. Berkeley-street, Birmingham.
*Mayne, Rev. Charles, M.R.I.A. 22 Upper Merrion-street, Dublin.

Year of Election.

1857. †*Mayne, William Annesley. Dublin.*
1863. §Mease, George D. Bylton Villa, South Shields.
1863. §Mease, Solomon. North Shields.
†Meath, Samuel Butcher, D.D., Lord Bishop of. 13 Fitzwilliam-square West, Dublin; and Ardbraccan, Co. Meath.
1861. §Medcalf, William. 20 Bridgewater-place, Manchester.
1863. §Meier, R. Newcastle-upon-Tyne.
1866. §Mello, Rev. J. M. Brampton, Chesterfield.
1854. †*Melly, Charles Pierre. Liverpool.*
1847. †Melville, Professor Alexander Gordon, M.D. Queen's College, Galway.
1863. †Melvin, Alexander. 42 Buccleuch-place, Edinburgh.
1862. §Mennell, Henry. St. Dunstan's-buildings, Great Tower-street, London, E.C.
1863. §Messent, P. T. 4 Northumberland-terrace, Tynemouth.
1847. †*Meyer, Charles, D.C.L.*
1847. *Michell, Rev. Richard, B.D. St. Giles's-street, Oxford.
1865. †Michie, Alexander. 26 Austin Friars, London.
1865. §Middlemore, William. Edgbaston, Birmingham.
1866. §Midgley, John. Colne, Lancashire.
1855. †Miles, Rev. Charles P., M.D., Principal of the Malta Protestant College, St. Julian's, Malta. 58 Brompton-crescent, London, S.W.
1857. †*Millar, George M.*
1850. †*Millar, James S. 9 Roxburgh-street, Edinburgh.*
1859. †Millar, John. Lisburn, Ireland.
1863. §Millar, John, M.D., F.L.S., F.G.S. Bethnal House, Cambridge-road, London, N.E.
Millar, Thomas, M.A. Perth.
1859. †Miller, James, jun. Greenock.
1865. †Miller, Rev. J. C., D.D. The Vicarage, Greenwich, London, S.E.
*Miller, Patrick, M.D. Exeter.
1861. *Miller, Robert. 30 King-street; and Whalley Range, Manchester.
1863. †Miller, Thomas. Righill Hall, Durham.
*Miller, William Allen, M.D., Treas. and V.P.R.S., Pres. Chem. Soc., Professor of Chemistry in King's College, London.
Miller, William Hallows, M.A., For. Sec. R.S., F.G.S., Professor of Mineralogy in the University of Cambridge. 7 Scroope-terrace, Cambridge.
1842. Milligan, Robert. Acacia in Randon, Leeds.
*Mills, John Robert. Bootham, York.
1851. †*Mills, Rev. Thomas.*
1847. †Milman, The Very Rev. H. H., Dean of St. Paul's, London.
Milne, Rear-Admiral Sir Alexander, K.C.B., F.R.S.E. Musselborough, Edinburgh.
*Milne-Home, David, M.A., F.R.S.E. Wedderburn, Coldstream, N.B.
1854. *Milner, William. Liverpool.
1854. *Milner, William Ralph. Wakefield, Yorkshire.
1864. †Milton, The Lord, M.P., F.R.G.S. Wentworth, Yorkshire.
1865. §Minton, Samuel, F.G.S. Oakham House, near Dudley.
1855. †Mirrlees, James Buchanan. 128 West-street, Tradeston, Glasgow.
1859. †Mitchell, Alexander, M.D. Old Rain, Aberdeen.
1863. †Mitchell, C. Walker, Newcastle-on-Tyne.
1855. †*Mitchell, George. Glasgow.*
1862. *Mitchell, William Stephen, LL.B., F.L.S., F.G.S. Caius College, Cambridge.
1855. *Moffat, John, C.E. Ardrossan.
1854. †Moffat, Thomas, M.D., F.G.S., F.R.A.S., M.B.M.S. Hawarden, Chester.
1864. †Mogg, John Rees. High Littleton House, near Bristol.

Year of Election.

1866. §Moggridge, Matthew, F.G.S. Richmond, Surrey.
1855. §Moir, James. 174 Gallogate, Glasgow.
1850. ‡*Moir, John, M.D. Edinburgh.*
1861. ‡Molesworth, Rev. W. N., M.A. Spotland, Rochdale.
Mollan, John, M.D. 8 Fitzwilliam-square North, Dublin.
1852. ‡Molony, William, LL.D. Carrickfergus.
1865. §Molyneux, William, F.G.S. Branston Cottage, Burton-upon-Trent.
1853. ‡Monday, William, Hon. Sec. Hull Lit. and Phil. Soc. 6 Jarratt-street, Hull.
1860. §Monk, Rev. William, M.A., F.R.A.S. Wymington Rectory, Hyham, Ferrers, Northamptonshire.
1853. ‡Monroe, Henry, M.D. 10 North-street, Sculcoates, Hull.
1850. ‡*Monteith, Alexander E. Inverleith House.*
Montgomery, Matthew Glasgow.
1846. ‡*Moody, T. H. C.*
1857. §Moore, Arthur. Cradley House, Clifton, Bristol.
1859. §Moore, Charles, F.G.S. 6 Cambridge-terrace, Bath.
1857. ‡Moore, Rev. Dr. Clontarf, Dublin.
Moore, John. 2 Mendiam-place, Clifton, Bristol.
*Moore, John Carrick, M.A., F.R.S., F.G.S. Corswall, Wigtonshire.
1866. *Moore, Thomas. Botanic Gardens, Chelsea, London, S.W.
1854. ‡Moore, Thomas John. Derby Museum, Liverpool.
Moore, William D. 7 South Anne-street, Dublin.
1857. *Moore, Rev. William Prior. The College, Cavan, Ireland.
1861. ‡Morewood, Edmund. Cheam, Surrey.
*Morgan, Captain Evan, R.A.*
1849. ‡Morgan, William. 37 Waterloo-street, Birmingham.
Morley, George. Park-place, Leeds.
1863. §Morley, Samuel. Lenton-grove, Nottingham.
1865. *Morrieson, Captain Robert. Oriental Club, Hanover-square, London, W.
1861. *Morris, David. 1 Market-place, Manchester.
1845. ‡Morris, Edward, M.D. Hereford.
*Morris, Rev. Francis Orpen, B.A. Nunburnholme Rectory, Hayton, York.
Morris, Samuel, M.R.D.S. Fortview, Clontarf, near Dublin.
1861. ‡Morris, William. The Grange, Salford.
1863. ‡Morrow, R. J. Bentick Villas, Newcastle.
1865. §Mortimer, J. R. Fimber, Malton.
1857. §Morton, George H., F.G.S. 9 London-road, Liverpool.
1858. *Morton, Henry Joseph. Garforth House, West Garforth, near Leeds.
1847. ‡Moseley, Rev. Henry, M.A., F.R.S. 13 Great George-street, Westminster.
1857. ‡Moses, Marcus. 4 Westmoreland-street, Dublin.
1862. ‡*Mosheimer, Joseph.*
Mosley, Sir Oswald, Bart., D.C.L., F.L.S., F.G.S. Rolleston Hall, Burton-upon-Trent, Staffordshire.
Moss, John. Otterspool, near Liverpool.
1853. *Moss, W. H. Kingston-terrace, Hull.
1864. §Mosse, J. R. General Manager's Office, Mauritius Railway, Port Louis, Mauritius.
1865. §Mott, Charles Grey. The Park, Birkenhead.
1866. §Mott, Frederick. Loughborough.
1862. *Mouat, Frederick John, M.D., Inspector-General of Prisons, Bengal. 45 Arundel-gardens, Notting-hill, London.
1856. ‡Mould, Rev. J. G., B.D. 21 Camden-crescent, Bath.
1863. ‡Mounsey, Edward. Sunderland.
Mounsey, John. Sunderland.

1861. *Mountcastle, William Robert. 22 Dorking-terrace, Cecil-street, Greenheys, Manchester.
Mowbray, James. Combus, Clackmannan, Scotland.
1850. ‡Mowbray, J. T. 27 Dundas-street, Edinburgh.
1855. §Muir, William. 10 St. John-street, Adelphi, London, W.C.
Muirhead, James. 90 Buchanan-street, Glasgow.
1852. ‡Mullan, William. Belfast.
1857. ‡Mullins, M. Bernard, M.A., C.E. 1 Fitzwilliam-square South, Dublin.
Munby, Arthur Joseph. 6 Fig-tree-court, Temple, London, E.C.
1866. §Mundella, A. J. The Park, Nottingham.
1864. *Munro Colonel William. United Service Club, Pall Mall, London, S.W.
1864. §Murch, Jerom. Cranwells, Bath.
*Murchison, John Henry, F.G.S. Surbiton-hill, Kingston.
1864. *Murchison, K. R. Manor House, Bathford, Bath.
*Murchison, Sir Roderick Impey, Bart., K.C.B., M.A., D.C.L. Oxon., LL.D. Camb., F.R.S., F.G.S., F.R.G.S., Hon. Mem. R.S.Ed. & R.I.A., Director-General of the Geological Survey of the United Kingdom. 16 Belgrave-square, London.
1864. ‡Murchison, Captain R. M. Caerbaden House, Cleveland-walk, Bath.
1855. ‡Murdock, James B. 195 Bath-street, Glasgow.
1858. ‡Murgatroyd, William. Bank Field, Bingley.
Murley, Rev. C. H. South Petherton, Ilminster.
1856. ‡*Murley, Stephen.*
1852. ‡Murney, Henry, M.D. 10 Chichester-street, Belfast.
1852. ‡Murphy, Joseph John. Old Forge, Dunmarry, Co. Antrim.
1850. ‡*Murray, Andrew.*
1857. ‡*Murray, B. A.*
Murray, John, F.G.S., F.R.G.S. 50 Albemarle-street, London, W.; and Newsted, Wimbledon, Surrey.
1859. ‡Murray, John, M.D. Forres, Scotland.
*Murray, John, C.E. 11 Great Queen-street, Westminster, London, S.W.
‡Murray, Rev. John. Morton, near Thornhill, Dumfriesshire.
1863. ‡Murray, William. 34 Clayton-street, Newcastle-on-Tyne.
*Murton, James. Silverdale, near Lancaster.
Musgrave, The Venerable Charles, D.D., Archdeacon of Craven. Halifax.
1861. ‡Musgrove, John, jun. Bolton.
*Muspratt, James Sheridan, Ph.D., F.C.S. College of Chemistry, Liverpool.
1865. §Myers, Rev. E. 17 Summerhill-terrace, Birmingham.
1845. ‡Myers, Rev. Thomas. York.
1859. §Mylne, Robert William, F.R.S., F.G.S., F.S.A. 21 Whitehall-place, London, S.W.
1850. ‡Myrtle, J. Y., M.D. 113 Princes-street, Edinburgh.

1850. ‡Nachot, H. W., Ph.D. 59 George-street, Edinburgh.
1842. Nadin, Joseph. Manchester.
1855. ‡Napier, James R. 22 Blythwood-square, Glasgow.
1839. *Napier, Right Honourable Joseph. 4 Merrion-square, Dublin.
**Napier, Captain Johnstone.*
1855. ‡Napier, Robert. West Chandon, Gareloch, Glasgow.
Napper, James William L. Loughcrew, Oldcastle., Co. Meath.
1866. §Nash, D. W. Cheltenham.
1850. *Nasmyth, James. Penge Hurst, Kent.
Nasmyth, Robert, F.R.S.E. 5 Charlotte-square, Edinburgh.

Year of Election.

1864. †Natal, William Colenso, Lord Bishop of.
1860. †Neate, Charles, M.A., M.P. Oriel College, Oxford.
1850. †*Necker, Theodore. Geneva.*
1845. †Neild, Arthur. Ollernshaw, Whaleybridge, by Stockport.
1853. †Neill, William, Governor of Hull Jail. Hull.
*Neilson, James B.*
Neilson, Robert. Woolton-hill, Liverpool.
1855. †Neilson, Walter. 172 West George-street.
1865. †Neilson, W. Montgomerie. Glasgow.
1846. †*Neison, F. G. P.*
1861. *Nelson, William. Scotland Bridge, Manchester.
1849. †Nesbit, C. J. Lower Kennington-lane, London, S.
Ness, John. Helmsley, near York.
1866. *Nevill, Rev. Samuel Tarratt, B.A., F.L.S. Shelton Rectory, Manchester.
1861. †Nevill, Thomas Henry. 17 George-street, Manchester.
1857. †Neville, John, C.E., M.R.I.A. Dundalk, Ireland.
1852. †Neville, Parke, C.E. Town Hall, Dublin.
1842. New, Herbert. Evesham, Worcestershire.
Newall, Henry. Hare-hill, Littleborough, Lancashire.
*Newall, Robert Stirling. Gateshead-upon-Tyne.
Newberry, Rev. Thomas, M.A. The Rectory, Hinton, Ilminster, Somerset.
Newbigging, P. S. K., M.D. Edinburgh.
1866. *Newdegate, Albert L. 11 Stanhope-place, Hyde Park, London.
1854. *Newlands, James. 2 Clare-terrace, Liverpool.
1842. *Newman, Francis William. 1 Dover-place, Clifton, Bristol.
*Newman, William. Darley Hall, near Barnsley, Yorkshire.
1863. *Newmarch, William, F.R.S. Heath View, West Side, Clapham Common, London, S.
1853. †Newmarch, William, Secretary to Globe Insurance, Cornhill, London.
1866. *Newmarch, William Thomas. Heath View, West Side, Clapham-common, London, S.
1858. †Newsome, Thomas. Park-road, Leeds.
1860. *Newton, Alfred, M.A., F.L.S., Professor of Zoology in the University of Cambridge. Magdalen College, Cambridge.
1865. †Newton, Thomas Henry Goodwin. Clopton House, near Stratford-on-Avon.
Nicholl, Iltyd, F.L.S. Uske, Monmouthshire.
1848. †Nicholl, W. H. Uske, Monmouthshire.
1866. §Nicholson, Sir Charles, Bart., D.C.L., LL.D., M.D., F.G.S. 26 Devonshire Place, Portland-place, London, W.
*Nicholson, Cornelius, F.G.S. Welfield, Muswell-hill, London, N.
1861. *Nicholson, Edward. 28 Princess-street, Manchester.
*Nicholson, John A., A.M., M.B., Lic. Med., M.R.I.A. Balrath, Kells, Co. Meath.
1858. *Nicholson, William Nicholson. Roundhay Park, Leeds.
1850. †Nicol, J., Professor of Natural History in Marischal College, Aberdeen.
1851. †*Nicolay, Rev. C. G.*
1856. †*Niven, Rev. James.*
Niven, Ninian. Clonturk Lodge, Drumcondra, Dublin.
1864. †Noad, Henry M., Ph.D., F.R.S., F.C.S. 72 Hereford-road, Bayswater, London, W.
1854. †Noble, Matthew. 13 Bruton-street, Bond-street, London W.
1863. *Noble, Captain William R. Elswick Works, Newcastle-on-Tyne.
1860. *Nolloth, M. S., Captain R.N., F.R.G.S. St. Mary's Cottage, Peckham, London; and United Service Club, London.

[illegible]

[illegible] Messrs. W. Rutherford and Co., 14 Canada Dock, [illegible].

[illegible] Rev. M.A. Houghton-le-Spring, Co. Durham.

[illegible] Bart. Rathcow Castle, Co. Cork.

[illegible] Halifax.

[illegible] 2 Broomfield-road, Aston, Birmingham.

[illegible] Hill, Nottingham.

[illegible] The Right Hon. Marquis of. 145 [illegible] and Castle Ashby, Northamptonshire.

[illegible] Queen's College, Oxford.

[illegible] M.A., F.G.S. 22 Park-street, [illegible].

[illegible]

[illegible] Westgate-street, Ipswich.

[illegible]

[illegible] West Cowes, Isle of Wight.

[illegible]

[illegible]

[illegible]

[illegible] 11 Lower Gardiner-street, Dublin.

[illegible] Drumcondra, Newmarket-on-Fergus, Ireland.

[illegible]

1856. *[illegible] 16 Clarendon-square, Leamington.

[illegible] Sion-hill, Bath.

1856. *[illegible] Soc. Professor of Chemistry in the Medical School of St. Bartholomew's Hospital. [illegible], Surrey.

1857. ‡[illegible] 2 Chesters, Temple, Dublin.

1856. ‡[illegible] Woodhouse, Loughborough.

1858. ‡[illegible] Bank Lane House, Dundee.

*[illegible] Lecturer on the Institutes of Medicine in Marischal College, Aberdeen.

1853. ‡[illegible] *Dundee.*

1853. ‡[illegible] Bart. Inverquharity, N. B.

1853. ‡[illegible] *Rev. E. C.*

*[illegible] M.D., M.A. Derby.

1859. ‡[illegible] M.D. 18 Adelphi-court, Aberdeen.

1857. ‡O'Hagan, John. 20 Kildare-street, Dublin.

1862. ‡O'Kelly, Joseph, M.A. 51 Stephen's Green, Dublin.

1857. ‡O'Kelly, Matthias J. Dalkey, Ireland.

1853. §Oldham, James, C.E. Austrian Chambers, Hull.

1857. *Oldham, Thomas, M.A., LL.D., F.R.S., F.G.S., M.R.I.A., Director of the Geological Survey of India. Calcutta.

1860. ‡O'Leary, Professor Purcell, M.A. Sydney-place, Cork.

1853. ‡Oliver, D. Richmond, Surrey.

*Ommanney, Erasmus, Rear-Admiral, C.B., F.R.A.S., F.R.G.S. 6 Talbot-square, Hyde-park, London, W.; and United Service Club, Pall Mall, London, S.W.

1847. **Orlebar, A. B., M.A.*

1842. Ormerod, George Wareing, M.A., F.G.S. Chagford, Exeter.

1861. ‡Ormerod, Henry Mere. Clarence-street, Manchester; and 11 Woodland-terrace, Cheetham-hill, Manchester.

1858. §Ormerod, T. T. Brighouse, near Halifax.

Orpen, John H., LL.D., M.R.I.A. (*Local Treasurer.*) 58 Stephen's Green, Dublin.

Year of Election.

1854. †Orr, Sir Andrew. Blythwood-square, Glasgow.
1865. †Osborne, E. C. Carpenter-road, Edgbaston, Birmingham.
*Osler, A. Follett, F.R.S. South Bank, Edgbaston, Birmingham.
1865. *Osler, Henry F. Portland-road, Edgbaston, Birmingham.
**Ossalinski, Count.*
1854. §Outram, Thomas. Greetland, near Halifax.
Ovenend, Wilson. Sharrow Head, Sheffield.
Overston, Samuel Jones Lloyd, Lord, F.G.S. 22 Norfolk-street, Park-lane, London; and Wickham Park, Bromley.
1857. †Owen, James H. Park House, Sandymount, Co. Dublin.
Owen, Richard, M.D., D.C.L., LL.D., F.R.S., F.L.S., F.G.S., Hon. M.R.S.E., Director of the Natural History Department, British Museum. Sheen Lodge, Mortlake, Surrey, S.W.
1863. *Ower, Charles. Dundee.
Oxford, Samuel Wilberforce, D.D., Lord Bishop of, F.R.S., F.S.A., F.R.G.S. 26 Pall Mall, London, S.W.; and Cuddesdon Palace, Wheatley, Oxon.

1855. ‡Pagan, John M., M.D. West Regent-street, Glasgow.
1850. ‡Pagan, Samuel Alexander, M.D., F.R.S.E. Edinburgh.
1859. ‡Page, David, F.R.S.E., F.G.S. 44 Gilmore-place, Edinburgh.
1863. §Paget, Charles. Ruddington Grange, near Nottingham.
1845. ‡Paget, George E., M.D. Cambridge.
1847. ‡*Pakington, J. S., B.A.*
1863. ‡Palmer, C. M. Whitley Park, near Newcastle-on-Tyne.
1866. §Palmer, H. Goldsmith-street, Nottingham.
*Palmer, Sir William, Bart. Whitchurch-Canonicorum, Dorset.
1866. §Palmer, William. Canal-street, Nottingham.
Palmes, Rev. William Lindsay, M.A. The Vicarage, Hornsea, Hull.
1854. ‡Pare, William, F.S.S. Seville Iron Works, Dublin.
1857. *Parker, Alexander, M.R.I.A.. William-street, Dublin.
*Parker, Charles Stewart. Liverpool.
1863. ‡Parker, Henry. Low Elswick, Newcastle-on-Tyne.
1863. ‡Parker, Rev. Henry. Idlerton Rectory, Low Elswick, Newcastle-on-Tyne.
Parker, Joseph, F.G.S. Upton Chaney, Bitton, near Bristol.
1845. ‡Parker, J. W., jun. Strand, London, W.C.
Parker, Richard. Dunscombe, Cork.
Parker, Rev. William. Saham, Norfolk.
1865. *Parker, Walter Mantel. Warren-corner House, near Farnham, Surrey.
1853. ‡Parker, William. Thornton-le-Moor, Lincolnshire.
1861. ‡*Parkes, Alexander.*
1865. *Parkes, Samuel Hickling. 5 St. Mary's-row, Birmingham.
1864. §Parkes, William. 14 Park-street, Westminster.
1859. ‡Parkinson, Robert, Ph.D. Bradford, Yorkshire.
1863. ‡Parland, Captain. Stokes Hall, Jesmond, Newcastle-on-Tyne.
*Parnell, E. A.*
1862. §Parnell, John, M.A. Bodham House, Upper Clapton, London, N.E.
Parnell, Richard, M.D., F.R.S.E. 7 James's-place, Leith.
1854. ‡Parr, Alfred, M.D. New Brighton, Cheshire.
*Partington, James Edge.*
Partridge, Richard, F.R.S., Professor of Anatomy to the Royal Academy of Arts, and to King's College, London. 17 New-street, Spring-gardens, London, S.W.
1865. *Parsons, Charles Thomas. Edgbaston, Birmingham.
1855. ‡Paterson, William. 100 Brunswick-street, Glasgow.
1861. ‡Patterson, Andrew. Deaf and Dumb School, Old Trafford, Manchester.

Year of Election.

1863. ‡Patterson, H. L. Scott's House, near Newcastle-on-Tyne.
1863. ‡Patterson, John. 16 Bloomfield-terrace, Gateshead-on-Tyne.
1839. *Patterson, Robert, F.R.S. (*Local Treasurer.*) 6 College-square North, Belfast.
1863. ‡Pattinson, William. Felling, near Newcastle-on-Tyne.
1864. ‡Pattison, Dr. T. H. Edinburgh.
1863. §Paul, Benjamin H., Ph.D. 8 Gray's Inn-square, London, W.C.
*Paul, Henry. Edinburgh.*
1863. ‡Pavy, Frederick William, M.D., F.R.S., Lecturer on Physiology and Comparative Anatomy and Zoology at Guy's Hospital. 35 Grosvenor-street, London, W.
1864. ‡Payne, Edward Turner. 3 Sydney-place, Bath.
1851. ‡Payne, Joseph. 4 Kildare Gardens, Bayswater, London, W.
1866. §Payne, Joseph Frank. 4 Kildare-gardens, Bayswater, London, W.
1847. §Peach, Charles W. 30 Haddington-place, Leith-walk, Edinburgh.
1863. §Peacock, Richard Atkinson. St. Heliers, Jersey.
*Pearsall, Thomas John, F.C.S. Birkbeck Literary and Scientific Institution, Southampton-buildings, Chancery-lane, London.
1854. ‡Pearson, J. A. Woolton, Liverpool.
1853. ‡Pearson, Robert H. 1 Prospect House, Hull.
*Pearson, Rev. Thomas, M.A.*
1863. §Pease, H. F. Brinkburn, Darlington.
1852. ‡Pease, Joseph Robinson, J.P. Hesslewood.
1863. §Pease, Joseph W. Woodlands, Darlington.
1863. ‡Pease, J. W. Newcastle-on-Tyne.
1858. *Pease, Thomas, F.G.S. Henbury, near Bristol.
Peckitt, Henry. Carlton Husthwaite, Thirsk, Yorkshire.
1855. *Peckover, Alexander, F.R.G.S. Wisbeach, Cambridgeshire.
*Peckover, Algernon, F.L.S. Wisbeach, Cambridgeshire.
*Peckover, Daniel. Woodhall, Calverley, Leeds.
*Peckover, William, F.S.A. Wisbeach, Cambridgeshire.
*Pedler, Lieutenant-Colonel Philip Warren. Mutley House, near Plymouth.
*Peel, George. Soho Iron Works, Manchester.
1861. *Peile, George, jun. Shotley Bridge, near Gateshead-on-Tyne.
1861. *Peiser, John. Barnfield House, Oxford-street, Manchester.
1865. ‡Pemberton, Oliver. 18 Temple-row, Birmingham.
1861. *Pender, John. Mount-street, Manchester.
1856. §Pengelly, William, F.R.S., F.G.S. Lamorna, Torquay.
1855. ‡Penny, Frederick, Professor of Chemistry in the Andersonian University, Glasgow.
1849. ‡Pentland, J. B. 5 Ryder-street, St. James's, London, S.W.
1845. ‡Percy, John, M.D., F.R.S., F.G.S., Professor of Metallurgy in the Government School of Mines. Museum of Practical Geology, Jermyn-street, London.
*Perigal, Frederick. 28 Hereford-square, Brompton, London, S.W.
1856. ‡*Perkins, A. M.*
1861. ‡Perkins, Rev. George. St. James's View, Dickenson-road, Rusholme, near Manchester.
Perkins, Rev. R. B., D.C.L. Wotton-under-Edge, Gloucestershire.
1864. *Perkins, V. R. Wotton-under-Edge.
1861. ‡Perring, John Shae. 104 King-street, Manchester.
1866. §Perry, Arthur George. The Grove, Stanton-by-Dale, Nottingham.
Perry, The Right Rev. Charles, M.A., Bishop of Melbourne, Australia.
*Perry, Rev. S. G. F., M.A. Tottington Parsonage, near Bury.
*Peters, Edward. Temple-row, Birmingham.
1850. *Petit, Rev. John Louis. 9 New-square, Lincoln's Inn, London, W.C.

Year of Election.

1854. ‡Petrie, James, M.D. 13 Upper Parliament-street, Liverpool.
1861. *Petrie, John. Rochdale.
1846. ‡Petrie, William. Ecclesbourne Cottage, Woolwich.
Pett, Samuel, F.G.S. 7 Albert-road, Regent's Park, London, N.W.
*Peyton, Abel. Birmingham..*
1857. ‡*Phayre, George.*
1845. ‡Phelps, Rev. Robert, D.D. Cambridge.
1863. *Phené, John Samuel, F.R.G.S. 34 Oakley-street, Chelsea, London, S.W.
1853. *Philips, Rev. Edward. The Bank, near Chendle, Staffordshire.
1853. *Philips, Herbert. 35 Church-street, Manchester.
*Philips, Mark. The Park, near Manchester.
1863. ‡Philipson, Dr. 1 Saville Row, Newcastle-on-Tyne.
1856. *Phillipps, Sir Thomas, Bart., M.A., F.R.S. Middle-hill, near Broadway, Worcestershire.
1859. *Phillips, Major-General Sir Frowell. United Service Club, Pall Mall, London.
1850. ‡*Phillips, George. Liverpool.*
1862. ‡Phillips, Rev. George, D.D., Queen's College, Cambridge.
*Phillips, John, M.A., LL.D., D.C.L., F.R.S., F.G.S., Professor of Geology in the University of Oxford. Museum House, Oxford.
1859. ‡*Phillips, Major J. Scott.*
Philpott, The Right Rev. Henry, D.D., Lord Bishop of Worcester.
1864. §Pickering, William. 3 Bridge-street, Bath.
1861. ‡Pickstone, William. Radcliff Bridge, near Manchester.
1856. ‡Pierson, Charles. 3 Blenheim-parade, Cheltenham.
Pigott, J. H. Smith. Brockley Hall, Bristol.
1865. ‡Pike, L. Owen. 25 Carlton-villas, Maida Vale, London, W.
*Pike, Ebenezer. Besborough, Cork.
1864. ‡Pilditch, Thomas. Portway House, Frome.
1857. ‡Pilkington, Henry M., M.A., Q.C. 35 Gardner's-place, Dublin.
1863. *Pim, Commander Bedford C. T., R.N., F.R.G.S. Junior United Service Club, London, S.W.
Pim, George, M.R.I.A. Brennan's Town, Cabinteely, Dublin.
Pim, Jonathan. Harold's Cross, Dublin.
Pim, William H. Monkstown, Dublin.
1861. ‡Pincoffs, Simon. Crumpsall Lodge, Cheetham-hill, Manchester.
Pinney, Charles. Clifton, Bristol.
1859. ‡Pirrie, William, M.D. 238 Union-street West, Aberdeen.
1866. §Pitcairn, David. Westbank, Dundee.
1864. ‡Pitt, R. 5 Widcomb-terrace, Bath.
1865. ‡Plant, Thomas L. Camp-hill, and 33 Union-street, Birmingham.
1863. *Platt, John. Werneth Park, Oldham, Lancashire.
1842. Playfair, Lyon, C.B., Ph.D., LL.D., F.R.S. L. & E., V.P.C.S., Professor of Chemistry in the University of Edinburgh. 14 Abercromby-place, Edinburgh.
Plumptre, Charles Frederick, D.D., Master of University College, Oxford. University College, Oxford.
1857. ‡Plunkett, Thomas. Ballybrophy House, Borris-in-Ossory, Ireland.
1861. *Pochin, Henry Davis, F.C.S. Oakfield House, Salford.
1847. ‡Pococke, Rev. N., M.A. Queen's College, Oxford.
*Pollexfen, Rev. John Hutton, M.A., Rector of St. Runwald's, Colchester.
Pollock, A. 52 Upper Sackville-street, Dublin.
1862. *Polwhele, Thomas Roxburgh, M.A. Polwhele, Truro, Cornwall.
*Pontey, Alexander. Plymouth.
1854. ‡*Poole, Braithwaite.*
*Poppelwell, Matthew. Rosella-place, Tynemouth.

Year of Election.

*Porter, Rev. Charles, D.D.*
*Porter, Henry John Ker. Brampton, Huntingdon.
1846. †*Porter, John.*
1866. §Porter, R. Beeston, Nottingham.
Porter, Rev. T. H., D.D. Desertcrest, Co. Armagh.
1863. †Potter, D. M. Cramlington, near Newcastle-on-Tyne.
*Potter, Edmund, F.R.S. 10 Charlotte-street, Manchester.
Potter, Henry Glassford, F.L.S., F.G.S. Reform Club, London; and Jesmond High-terrace, Newcastle-on-Tyne.
Potter, Richard, M.A., F.C.P.S. Ampthill-square, Hampstead-road, London, N.W.
1842. Potter, Thomas. George-street, Manchester.
Potter, William. 34 Falkner-street, Liverpool.
1863. †Potts, James. 52½ Quayside, Newcastle-on-Tyne.
1857. *Pounden, Captain Landsdale, F.R.G.S. Junior United Service Club, London, S.W.; and Brownswood, Co. Wexford.
*Powell, Rev. Dr. Madras.*
1851. †*Power, David.*
1857. †Power, Sir James, Bart. Edermine, Enniscorthy, Ireland.
1850. †*Poynter, John. Glasgow.*
1855. *Poynter, John E. Clyde Neuck, Uddingstone, Hamilton, Scotland.
1846. †*Poyter, Thomas.*
1864. §Prangley, Arthur. 2 Burlington-buildings, Redland, Bristol.
*Pratt, Archdeacon, M.A., F.C.P.S. Calcutta.*
1864. *Prentice, Manning. Stowmarket, Suffolk.
Prest, Edward, Archdeacon. The College, Durham.
Preat, John. Blossom-street, York.
*Prestwich, Joseph, F.R.S., Treas. G.S. 2 Suffolk-lane, City, London, E.C.; and 10 Kent-terrace, Regent's Park-road, London, N.W.
*Pretious, Thomas. H.M. Dockyard, Devonport.
1846. †Priaulx, Nicholas M. 9 Brunswick-place, Southampton.
1856. *Price, Rev. Bartholomew, M.A., F.R.S., F.R.A.S., Sedleian Professor of Natural Philosophy in the University of Oxford. 11 St. Giles's-street, Oxford.
Price, J. T. Neath Abbey, Glamorganshire.
1865. †Prideaux, J. S. 209 Piccadilly, London, W.
1864. *Prior, R. C. A., M.D. Halse House, Taunton.
1865. *Prichard, Thomas, M.D. Avington Abbey, Northampton.
1835. *Pritchard, Andrew. 87 St. Paul's-road, Highbury, London, N.
1846. *Pritchard, Rev. Charles, M.A., F.R.S., Pres. R.A.S., F.G.S. Hurst-hill, Freshwater, Isle of Wight.
1863. †Procter, R. S. Summerhill-terrace, Newcastle-on-Tyne.
Proctor, Thomas. Clifton Down, Bristol.
Proctor, William. Cathay, Bristol.
1858. §Proctor, William, M.D., F.C.S. 24 Petergate, York.
1863. *Prosser, John. 38 Cumberland-road, Newcastle-on-Tyne.
1841. †Prosser, Richard. King's Norton, near Birmingham.
Protheroe, Captain W. G. B. Dolewilim, St. Clair's, Carnarvonshire.
1863. †Proud, Joseph. South Hetton, Newcastle-on-Tyne.
1849. †Proud, Thomas Aston. Villa-road, Handsworth.
*Prower, Rev. J. M., M.A. Swindon, Wiltshire.
1865. §Prowse, Albert P. Whitchurch Villa, Mannamead, Plymouth.
1854. †*Puckle, Hale G.*
1864. †Pugh, John. Aberdovey, Shrewsbury.
1859. †Pugh, William. Coalport, Shropshire.
1854. †*Pulsford, James.*
1842. *Pumphrey, Charles. 34 Frederick-street, Edgbaston, Birmingham.

Year of Election.

*Rawlins, John. Llewesog Hall, Denbighshire.
1866. *Rawlinson, George, Professor of History in the University of Oxford. Oxford.
1855. *Rawlinson, Major-General Sir Henry C., K.C.B., M.P., LL.D., F.R.S., F.R.G.S. 1 Hill-street, Berkeley-square, London, W.
*Rawson, Rawson William, F.R.G.S.*
*Rawson, Thomas William. Saville Lodge, Halifax.
1865. §Rayner, Henry. Lonsdale Villa, Smethwick, Birmingham.
1845. †*Read, Joseph, M.D.*
1852. †Read, Thomas, M.D. Donegal-square West, Belfast.
1865. §Read, William. Albion House, Epworth, Bawtry.
1858. †Read, William Henry. Chapel Allerton, near Leeds.
*Read, W. H. Rudstone, M.A., F.L.S. Hayton, near Pocklington, Yorkshire.
*Reade, Rev. Joseph Bancroft, M.A., F.R.S. Bishopbourne Rectory, Canterbury.
1862. *Readwin, Thomas Allison, F.G.S. Stretford, near Manchester.
1864. §Reddie, James, Hon. Sec. to the Victoria Institute or Philosophical Society of Great Britain. Bridge House, Hammersmith, London.
1852. *Redfern, Professor Peter, M.D. 4 Lower-crescent, Belfast.
1863. †Redmayne, Giles. 20 New Bond-street, London, W.
1863. †Redmayne, R. R. 12 Victoria-terrace, Newcastle.
Redwood, Isaac. Cae Wern, near Neath, South Wales.
1861. *Reé, H. P. 27 Faulkner-street, Manchester.
1861. †Reed, Edward J., Chief Constructor of the Navy. Admiralty, Whitehall, London, S.W.
1854. †*Reid, David Boswell, M.D.*
1850. †Reid, William, M.D. Cuivie, Cupar, Fife.
1849. †*Reid, Major-General Sir William.*
1863. §Renals, E. 'Nottingham Express' Office, Nottingham.
1863. †Rendel, G. Benwell, Newcastle-on-Tyne.
Rennie, Sir John, Knt., F.R.S., F.G.S., F.S.A., F.R.G.S. 32 Charing Cross, London, W.C.
1860. †Rennison, Rev. Thomas, M.A. Queen's College, Oxford.
**Renny, Lieutenant H. L., R.E. Montreal.*
1858. §Reynolds, Richard, F.C.S. 13 Briggate, Leeds.
1849. †Reynolds, Thomas F., M.D. 14 Lansdowne-terrace, Cheltenham.
Reynolds, William, M.D. Coeddu, near Mold, Flintshire.
1850. †Rhind, William. 121 Princes-street, Edinburgh.
1858. *Rhodes, John. Leeds.
1847. †Ricardo, M. Brighton.
1863. §Richardson, Benjamin W., M.A., M.D., F.R.S. 12 Hinde-street, Manchester-square, London, W.
1861. §Richardson, Charles. Almondbury, Bristol.
1863. *Richardson, Edward, jun. South Ashfield, Newcastle-on-Tyne.
Richardson, James. Glasgow.
1854. †Richardson, John. Hull.
1863. †Richardson, John W. South Ashfield, Newcastle-on-Tyne.
Richardson, Thomas. Glasgow.
Richardson, Thomas. Montpelier-hill, Dublin.
Richardson, William. Micklegate, York.
1861. §Richardson, William. 4 Edward-street, Werneth, Oldham.
*Richardson, Rev. William.*
1861. †Richson, Rev. Canon, M.A. Shakespeare-street, Ardwick, Manchester.
1863. †Richter, Otto, Ph.D. Bathgate, Linlithgowshire.
*Riddell, Major-General Charles James Buchanan, C.B., F.R.S. Athenæum Club, Pall Mall, London.

Year of Election.

1861. *Riddell, H. B. The Palace, Maidstone.
1859. ‡Riddell, Rev. John. Moffat by Beatlock, N. B.
1861. *Rideout, William J. Farnworth, near Manchester.
1862. ‡Ridgway, Henry Akroyd, B.A. Bank Field, Halifax.
Ridgway, John. Cauldon-place, Potteries, Staffordshire.
1861. §Ridley, John. 19 Belsize-park, Hampstead, London.
1863. ‡Ridley, Samuel. 7 Regent's-terrace, Newcastle-on-Tyne.
1863. *Rigby, Samuel. Bruch Hall, Warrington.
*Rinder, Miss. Gledhow Grove, Leeds.
1860. §Ritchie, George Robert. 4 Watkyn-Terrace, Coldharbour-lane, Camberwell, London.
1855. ‡Ritchie, Robert, C.E. 14 Hill-street, Edinburgh.
1853. ‡Rivay, John V. C. 19 Cowley-street, Westminster, London.
1854. ‡Robberds, Rev. John, B.A. Liverpool.
1855. ‡Roberton, James. Gorbals Foundry, Glasgow.
Roberton, John. Oxford-road, Manchester.
1859. ‡Roberts, George Christopher. Hull.
1850. ‡Roberts, Henry, F.S.A. Athenæum Club, London, S.W.
1854. ‡*Roberts, John.*
1853. ‡Roberts, John Francis. 10 Adam-street, Adelphi, London, W.C.
1857. ‡Roberts, Michael, M.A. Trinity College, Dublin.
*Roberts, William P. 50 Ardwick Green, Manchester.
1859. ‡Robertson, Dr. Andrew. Indego, Aberdeen.
1866. §Robertson, A. S., M.D., F.R.G.S. Horwick, Lancashire.
1866. §Robertson, William Tindal, M.D. Nottingham.
1863. ‡*Robinson, Dr.*
1861. ‡Robinson, Enoch. Dukinfield, Cheshire.
1852. ‡Robinson, Rev. George. Tartaragham Glebe, Loughgall, Ireland.
1864. §Robinson, George Augustus. Widcomb-hill, Bath.
1859. ‡Robinson, Hardy. 166 Union-street, Aberdeen.
1860. ‡*Robinson, Professor H. D.*
*Robinson, H. Oliver. 16 Park-street, Westminster, London.
1866. §Robinson, John. Museum, Oxford.
1861. ‡Robinson, John. Atlas Works, Manchester.
1863. ‡Robinson, J. H. Cumberland-row, Newcastle-on-Tyne.
1855. ‡Robinson, M. E. 116 St. Vincent-street, Glasgow.
1860. ‡Robinson, Admiral Robert Spencer. 61 Eaton-place, London, S.W.
Robinson, Rev. Thomas Romney, D.D., F.R.S., F.R.A.S., M.R.I.A., Director of the Armagh Observatory. Armagh.
1863. ‡Robinson, T. W. U. Houghton-le-Spring, Durham.
1863. *‡*Robson, James.*
*Robson, Rev. John, D.D. Glasgow.
1855. ‡Robson, Neil, C.E. 127 St. Vincent-street, Glasgow.
1845. ‡*Rocow, Tattersall Thomas.*
1851. ‡Rodwell, William. Woodlands, Holbrook, Ipswich.
Roe, Henry, M.R.I.A. 2 Fitzwilliam-square East, Dublin.
1866. §Roe, Thomas. Grove Villas, Sitchurch.
1846. ‡Roe, William Henry. Portland-terrace, Southampton.
1861. §Rofe, John, F.G.S. Queen-street, Lancaster.
1860. ‡Rogers, James E. T., Professor of Political Economy in the University of Oxford. Beaumont-street, Oxford.
*Roget, Peter Mark, M.D., F.R.S. 18 Upper Bedford-place, Russell-square, London, W.C.
1859. †Rolleston, George, M.A., M.D., F.R.S., F.L.S., Professor of Anatomy and Physiology in the University of Oxford. 15 New Inn Hall-street, Oxford.
1866. §Rolph, George Frederick. War Office, Horse Guards, London, S.W.
1863. ‡Romilly, Edward. 14 Hyde Park-terrace, London, W.

Year of Election.

1845. †*Romily, Rev. Joseph.*
1845. †Ronalds, Francis, F.R.S. 9 St. Mary's-villas, Battle, Essex.
1846. †Ronalds, Edmund, Ph.D. Stewartfield, Bonnington, Edinburgh.
1865. †Roper, R. S. Newport, Monmouthshire.
1861. *Roscoe, Henry Enfield, B.A., Ph.D., F.R.S., F.C.S., Professor of Chemistry in Owens College, Manchester.
1861. §Rose, C. B., F.G.S. 25 King-street, Great Yarmouth, Norfolk.
Rosebery, Archibald John, Earl of, K.T., M.A., D.C.L., F.R.S. 139 Piccadilly, London; and Dalmeny Park, Linlithgow.
1863. †Roseby, John. Haverholme House, Brigg, Lincolnshire.
1851. †*Rosling, Alfred.*
1857. †Ross, David, LL.D. Drumbrain Cottage, Newbliss, Ireland.
1859. *Ross, James Coulman. Trinity College, Cambridge.
1861. *Ross, Thomas. Featherstone-buildings, High Holborn, London, W.C.
1842. Ross, William. Pendleton, Manchester.
Rosse, William, Earl of, M.A., K.St.P., LL.D., F.R.S., F.R.A.S., F.G.S., M.R.I.A., F.R.G.S., F.A.S., Chancellor of the University of Dublin. Birr Castle, Parsonstown, King's County, Ireland.
Rosson, John. Moore Hall, near Ormskirk, Lancashire.
1855. †Roth, Dr. Matthias. 16A Old Cavendish-street, London, W.
1865. *Rothera, George Bell. 39 Upper Talbot-street, Nottingham.
1846. †Roundall, William B. 146 High-street, Southampton.
*Roundell, Rev. Danson Richardson. Gledstone, Skipton.
1849. §Round, Daniel G. Hange Colliery, near Tipton, Staffordshire.
1847. †Rouse, William. 16 Canterbury Villas, Maida Vale, London, W.
1861. †Routh, Edward J., M.A. St. Peter's College, Cambridge.
1861. †Rowan, David. St. Vincent Crescent, Glasgow.
1855. †Rowand, Alexander. Linthouse, near Glasgow.
1865. §Rowe, Rev. John. Beaufort-villas, Edgbaston, Birmingham.
1855. *Rowney, Thomas H., Ph.D., F.C.S., Professor of Chemistry in Queen's College, Galway.
*Rowntree, Joseph. Leeds.
1862. †Rowsell, Rev. Evan Edward, M.A. Hambledon Rectory, Godalming.
1861. *Royle, Peter, M.D., L.R.C.P., M.R.C.S. 27 Lever-street, Manchester.
1859. †*Ruland, C. H.*
1861. *Rumney, Robert, F.C.S. Ardwick, Manchester.
1856. †Rumsay, Henry Wildbore. Gloucester Lodge, Cheltenham.
1847. †Ruskin, John, M.A., F.G.S. Denmark-hill, Camberwell, London, S.
1857. †Russell, Rev. C. W., D.D. Maynooth College.
1855. †Russell, James, jun. Falkirk.
1865. †Russell, James, M.D. 91 Newhall-street, Birmingham.
1859. †Russell, John, the Right Hon. Earl, K.G., F.R.S., F.R.G.S. 37 Chesham-place, Belgrave-square, London, S.W.
*Russell, John.*
Russell, John. 15 Middle Gardiner's-street, Dublin.
Russell, John Scott, M.A., F.R.S. L. & E. Sydenham; and 5 Westminster Chambers, Westminster, London.
1852. *Russell, Norman Scott. 37 Great George-street, Westminster, London.
1853. †*Russell, Robert.*
1863. †Russell, Robert. Gosforth Colliery, Newcastle-on-Tyne.
*Russell, Rev. T.*
1852. *Russell, William J., Ph.D. 34 Upper Hamilton-terrace, St. John's Wood, London.
1862. §Russell, W. H. L., A.B., F.R.S. Shepperton, Middlesex.
1865. †Rust, Rev. James, M.A. Manse of Slains, Ellon, N. B.
Rutson, William. Newby Wiske, Northallerton, Yorkshire.
1852. †*Ryan, John, M.D.*
*Ryland, Arthur. Birmingham.

Year of Election.

1865. §Ryland, Thomas. The Redlands, Erdington, Birmingham.
1853. ‡Rylands, Joseph. 9 Charlotte-street, Hull.
1861. *Rylands, Thomas Glazebrook. Heath House, Warrington.

*Sabine, Major-General Edward, R.A., LL.D., D.C.L., President of the Royal Society, F.R.A.S., F.L.S., F.R.G.S. 13 Ashley-place, Westminster, London.
1865. ‡Sabine, Robert. (Care of C. W. Siemens, Esq.), 8 George-street, Westminster.
1866. *St. Albans, His Grace the Duke of. Brestwood Hall, near Nottingham.
Salkeld, Joseph. Penrith, Cumberland.
1857. ‡Salmon, Rev. George, D.D., F.R.S., Professor of Divinity in Trinity College. Trinity College, Dublin.
1864. ‡*Salmon, Henry C., F.G.S., F.C.S.*
Salmon, William Wroughton. 9 Regent's Park-square, London, N.W.; and Devizes, Wiltshire.
1854. *Salt, Charles F. 24 Grove-street, Liverpool.
1858. *Salt, Titus. Crow Nest, Lightcliffe, Halifax.
1856. ‡Salter, John William, F.G.S. Geological Survey of Great Britain, Museum of Practical Geology, Jermyn-street; and 8 Bolton-road, Boundary-road, St. John's Wood, London, N.W.
1842. Sambrooke, T. G. 32 Eaton-place, London, S.W.
1861. *Samson, Henry. Messrs. Samson and Leppoe, St. Peter's-square, Manchester.
1854. ‡Sandbach, Henry R. Hafodunos, Denbighshire.
1861. *Sandeman, A., M.A. Queen's College, Cambridge.
1857. ‡Sanders, Gilbert. The Hill, Monkstown, Co. Dublin.
Sanders, John Naish, F.G.S. 12 Vyvyan-terrace, Clifton, Bristol.
*Sanders, William, F.R.S., F.G.S. (*Local Treasurer.*) 21 Richmond-terrace, Clifton, Bristol.
Sandes, Thomas, A.B. Sallow Glin, Tarbert, Co. Kerry.
1864. §Sandford, William. 9 Springfield-place, Bath.
1854. ‡Sandon, Lord. 39 Gloucester-square, London, W.
1864. §Sanford, William A. Nynehead Court, Wellington, Somersetshire.
1865. ‡Sargant, W. L. Edmund-street, Birmingham.
Satterfield, Joshua. Alderley Edge.
1861. ‡Saul, Charles J. Smedley-lane, Cheetham-hill, Manchester.
1846. ‡*Saunders, Trelawney William.*
1864. ‡Saunders, T. W., Recorder of Bath. 1 Priory-place, Bath.
1860. *Saunders, William. Manor House, Iffley, near Oxford.
1863. ‡Savory, Valentine. Cleckheaton, near Leeds.
1857. ‡Scallan, James Joseph. 77 Harcourt-street, Dublin.
1850. ‡Scarth, Pillans. 28 Barnard-street, Leith.
*Schemman, J. C. Hamburg.*
*Schlick, Commandeur de.*
1842. *Schofield, Benjamin.*
1842. Schofield, Joseph. Stubley Hall, Littleborough, Lancashire.
1842. Schofield, W. F. Fairlawn, Ripon.
*Scholes, T. Seddon. 16 Dale-street, Leamington.
1847. *Scholey, William Stephenson, M.A. Freemantle Lodge, Castle-hill, Reading.
*Scholfield, Edward, M.D. Doncaster.
1854. ‡*Scholfield, Henry D., M.D.*
Schunck, Edward, F.R.S. Oaklands, Kersall Moor, Manchester.
1861. *Schwabe, Edmund Salis. Rhodes House, near Manchester.
1847. ‡Sclater, Philip Lutley, M.A, Ph.D., F.R.S., F.L.S., Sec. Zool. Soc. 11 Hanover-square, London, W.

Year of Election.

1849. ‡Scoffern, John, M.B. Barnard's Inn, London; and Ilford, Essex.
1865. §Scott, Major-General, Royal Bengal Artillery. Treledan Hall, Montgomeryshire.
1859. ‡Scott, Captain Fitzmaurice. Forfar Artillery.
1855. ‡Scott, Montague D., B.A. Hove, Sussex.
1857. §Scott, Robert H., F.G.S., Director of the Meteorological Office, 2 Parliament-street, London, S.W.
1861. §Scott, Rev. Robert Selkirk, M.A. 7 Beaufort-terrace, Cecil-street, Manchester.
1864. ‡Scott, Wentworth Lascelles, F.C.S. Cornwall-villa, 24 Cornwall-road, Westbourne Park, London, W.
1858. ‡Scott, William. Holbeck, near Leeds.
1864. ‡Scott, William Robson, Ph.D. St. Leonards, Exeter.
1856. ‡*Scougall, James.*
1854. ‡Scrivenor, Harry. Ramsay, Isle of Man.
1859. ‡Seaton, John Love. Hull.
*Sedgwick, Rev. Adam, M.A., LL.D., F.R.S., Hon. M.R.I.A., F.G.S., F.R.A.S., F.R.G.S., Woodwardian Professor of Geology in the University of Cambridge, and Canon of Norwich. Trinity College, Cambridge.
1853. ‡Sedgwick, Rev. James. Scalby Vicarage, Scarborough.
1861. *Seeley, Harry, F.G.S. Woodwardian Museum, Cambridge.
Selby, Prideaux John, F.L.S., F.G.S. Twizel House, Belford, Northumberland.
1855. ‡Seligman, H. L. 135 Buchanan-street, Glasgow.
1850. ‡Seller, William, M.D. 23 Nelson-street, Edinburgh.
*Selwyn, Rev. William, M.A., Prebendary of Ely. Foxton, Royston.
1858. *Senior, George, F.S.S. Regent-street, Barnsley.
Seymour, George Hicks. Stonegate, York.
1861. *Seymour, Henry D., M.P. 39 Upper Grosvenor-street, London, W.
Seymour, John. 21 Bootham, York.
1853. ‡Shackles, G. L. 6 Albion-street, Hull.
*Shaen, William. 8 Bedford-row, London.
1846. ‡Sharp, James. 22 Oxford-street, Southampton.
Sharp, Rev. John, B.A. Horbury, Wakefield.
1861. §Sharp, Samuel, F.G.S., F.S.A. Dallington Hall, near Northampton.
*Sharp, William, M.D., F.R.S., F.G.S. Horton House, Rugby.
Sharp, Rev. William, B.A. Mareham Rectory, near Boston, Lincolnshire.
1854. ‡*Sharpe, Robert, M.D.*
Sharpey, William, M.D., LL.D., Sec. R.S., F.R.S.E., Professor of Anatomy in University College. 33 Woburn-place, London, W.
1858. *Shaw, Bentley. Woodfield House, Huddersfield.
1854. *Shaw, Charles Wright. 3 Windsor-terrace, Douglas, Isle of Man.
1858. ‡*Shaw, Edward W.*
1865. ‡Shaw, George. Cannon-street, Birmingham.
1845. ‡Shaw, John, M.D., F.L.S., F.G.S. Boston, Lincolnshire.
1861. *Shaw, John. City-road, Hulme, Manchester.
1858. ‡Shaw, John Hope. Headingley, Leeds.
1853. ‡Shaw, Norton, M.D. St. Croix, West Indies.
Shepard, John. Nelson-square, Bradford, Yorkshire.
1863. ‡Shepherd, A. B. 7 South-square, Gray's Inn, London, W.C.
Sheppard, Rev. Henry W., B.A. The Parsonage, Emsworth, Hants.
*Sherrard, David Henry. 88 Upper Dorset-street, Dublin.
1851. ‡Shewell, John T. Rushmere, Ipswich.
1866. §Shilton, Samuel Richard Parr. Snenton House, Nottingham.
1849. ‡Shorthouse, Joseph. Birmingham.

Year of Election.

1846. *Shortrede, Colonel Robert, F.R.A.S. The Bowans, Lee-road, Blackheath, S.E.
1864. §Showers, Lieut.-Colonel Charles L. Cox's Hotel, Jermyn-street, London, S.W.
1842. Shuttleworth, John. Wilton Polygon, Cheetham-hill, Manchester.
1866. §Sibson, Francis, M.D., F.R.S. 40 Brook-street, Grosvenor-square, London, W.
1861. *Sidebotham, Joseph. 19 George-street, Manchester.
1861. *Sidebottom, James. Portland-street, Manchester.
1861. *Sidebottom, James, jun. Spring-bank Mills, Stockport.
1857. †Sidney, Frederick John. 19 Herbert-street, Dublin.
Sidney, M. J. F. Cowpen, Newcastle-upon-tyne.
1856. §Siemens, C. William, F.R.S. 3 Great George-street, Westminster, London.
*Sigmond, George, M.D., F.S.A.*
*Sillar, Zechariah, M.D. Bath House, Laurie Park, Sydenham, London, S.
1859. †Sim, John. Hardgate, Aberdeen.
1855. †Sim, William. Furnace, near Inverary.
1851. †Sim, W. D. Ipswich.
1865. §Simkiss, T. M. 38 Waterloo-road South, Wolverhampton.
1862. §Simms, James. 138 Fleet-street, London, E.C.
1852. †Simms, William. Albion-place, Belfast.
1847. †Simon, John. King's College, London, W.C.
1866. §Simons, George. The Park, Nottingham.
1850. †*Simpson, Professor James Y.*
1859. †Simpson, John. Marykirk, Kincardineshire.
1863. §Simpson, J. B., F.G.S. Hedgefield House, Blaydon-on-Tyne.
1857. †*Simpson, Max, M.D.*
*Simpson, Rev. Samuel. Douglas, Isle of Man.
Simpson, Thomas. Blake-street, York.
Simpson, William. Bradmore House, Hammersmith, London, W.
1859. †Sinclair, Alexander. 133 George-street, Edinburgh.
1850. †Sinclair, Rev. William. Leeds.
1864. *Sircar, Baboo Mohendro Lall, M.D. 1344 San Kany, Tollah-street, Calcutta, per Messrs. Harrenden & Co., 3 Chaple-place, Poultry, London, E.C.
*Sirr, Rev. Joseph D'Arcy, D.D., M.R.I.A. Castle-hill, Winchester.
Sisson, William, F.G.S. Clifton, Bristol.
1865. §Sissons, W. Saw Mills, Hull.
1850. †Skae, David, M.D. Royal Asylum, Edinburgh.
1850. †*Skene, William Forbes.*
1859. †*Skinner, James.*
1849. †*Slaney, R. A. Shropshire.*
1842. *Slater, William. Princess-street, Manchester.
1853. §Sleddon, Francis. 2 Kingston-terrace, Hull.
1849. §Sloper, George Edgar, jun. Devizes.
1849. †Sloper, Samuel W. Devizes.
1860. §Sloper, S. Elgar. Winterton, near Southampton.
1858. †Smeeton, G. H. Commercial-street, Leeds.
1857. †Smith, Aquila, M.D., M.R.I.A. 121 Lower Bagot-street, Dublin.
Smith, Archibald, M.A., F.R.S. L. & E. River-bank, Putney; and 3 Stone-buildings, Lincoln's Inn, London, W.C.
1860. §Smith, Brooke. 51 Frederick-street, Edgbaston, Birmingham.
*Smith, Rev. B., F.S.A.*
1861. *Smith, Charles Edward, F.R.A.S. Fir Vale, near Sheffield.
1865. †Smith, David, F.R.A.S. 4 Cherry-street, Birmingham
1853. †Smith, Edmund. Ferriby, near Hull.

Year of Election.

1859. §Smith, Edward, M.D., LL.B., F.R.S. 16 Queen Anne-street, London, W.
1865. ‡Smith, Frederick. The Priory, Dudley.
1866. *Smith, F. C. Bramcote, Nottingham.
1855. ‡Smith, George. Port Dundas, Glasgow.
1855. ‡Smith, George Cruickshank. 19 St. Vincent-place, Glasgow.
*Smith, Rev. George Sidney, D.D., M.R.I.A., Professor of Biblical Greek in the University of Dublin. Aughalurcher, Five-mile-Town, Co. Tyrone.
1859. ‡Smith, G. Campbell. Banff.
1859. ‡Smith, Henry A. 5 East Craibstone-street, Aberdeen.
*Smith, Henry John Stephen, M.A., F.R.S., Savilian Professor of Geometry in the University of Oxford. 64 St. Giles's, Oxford.
1860. *Smith, Heywood., M.A., M.B. 25 Park-street, Grosvenor-square, London, W.
1845. ‡*Smith, Horatio. Manchester.*
1865. §Smith, Isaac. 26 Lancaster-street, Birmingham.
1842. *Smith, James. Berkeley House, Seaforth, near Liverpool.
Smith, James, F.R.S. L. & E., F.G.S., F.R.G.S. Athenæum Club, London, S.W.; and Jordan-hill, Glasgow.
1859. ‡*Smith, James. Gibraltar.*
1855. ‡Smith, James. St. Vincent-street, Glasgow.
*Smith, John. Shelbrook House, Ashby-de-la-Zouch.
1850. ‡*Smith, John, M.D. Edinburgh.*
1853. ‡Smith, John. York City and County Bank, Malton, Yorkshire.
1858. *Smith, John Metcalf. (*Local Treasurer.*) Bank, Leeds.
Smith, John Peter George. Liverpool.
1864. §Smith, John S. Sydney Lodge, Wimbledon, Surrey.
1852. *Smith, Rev. Joseph Denham. Kingstown, near Dublin.
1861. ‡Smith, Professor J., M.D. University of Sydney, Australia.
1845. ‡Smith, Rev. J. J. Caius College, Cambridge.
*Smith, Rev. Philip, B.A. 33 Upper Bedford-place, London, W.C.
1860. *Smith, Protheroe, M.D. 25 Park-street, Grosvenor-square, London, W.
1837. Smith, Richard Bryan. Villa Nova, Shrewsbury.
1847. ‡Smith, Robert Angus, Ph.D., F.R.S., F.C.S. 20 Grosvenor-square, Manchester.
*Smith, Robert Mackay. Bellevue-crescent, Edinburgh.
1866. §Smith, Samuel. 33 Compton-street, Goswell-road, London, E.C.
1859. ‡Smith, Thomas James, F.G.S., F.C.S. Hessle, near Hull.
1852. ‡Smith, William. Eglinton Engine Works, Glasgow.
1857. §Smith, William, C.E., F.G.S. 19 Salisbury-street, Adelphi, London, W.C.
1850. *Smyth, Charles Piazzi, F.R.S. L. & E., F.R.A.S., Astronomer Royal for Scotland, Professor of Practical Astronomy in the University of Edinburgh. 1 Hillside-crescent, Edinburgh.
1846. ‡*Smyth, Rev. George Watson.*
1857. *Smyth, John, jun., M.A., C.E. Milltown, Banbridge, Ireland.
1864. ‡Smyth, Warington W., M.A., F.R.S., Pres. G.S., Lecturer on Mining at the Government School of Mines, and Inspector of the Mineral Property of the Crown. 27 Victoria-street, London, S.W.
1854. ‡Smythe, Lieut.-Col. W. J., R.A. Woolwich.
Soden, John. Athenæum Club, Pall Mall, London, S.W.
1853. ‡Sollitt, J. D., Head Master of Grammar School, Hull.
*Solly, Edward, F.R.S., F.S.A. Holme Court, Isleworth, Middlesex.
*Solly, Samuel Reynolds, M.A., F.R.S. 10 Manchester-square, London.

Year of Election.

*Sopwith, Thomas, M.A., F.R.S., F.G.S., F.R.G.S. 103 Victoria-street, Westminster, London.
Sorbey, Alfred. The Rookery, Ashford, Bakewell.
1859. *Sorby, H. Clifton, F.R.S., F.G.S. Broomfield, Sheffield.
1861. ‡Sorensen, Le Chevalier B. Norway.
1865. *Southall, John Tertius. Leominster.
1859. ‡Southall, Norman. 44 Cannon-street West, London, E.C.
1856. ‡Southwood, Rev. T. A. Cheltenham College.
1863. ‡Sowerby, John. Shipcote House, Gateshead, Durham.
1863. *Spark, H. King. Greenbank, Darlington.
1859. ‡Spence, Rev. James, D.D. 6 Clapton-square, London, N.E.
*Spence, Joseph. Pavement, York.
1854. §Spence, Peter. Pendleton Alum Works, Newton Heath; and Smedley Hall, near Manchester.
1845. ‡*Spence, W. B.*
1861. §Spencer, John Frederick. St. Nicholas-buildings, Newcastle-on-Tyne.
1861. *Spencer, Joseph. 27 Brown-street, Manchester.
1863. **Spencer, Thomas.*
1855. ‡Spens, William. 78 St. Vincent-street, Glasgow.
1864. *Spicer, Henry, jun. 22 Highbury-crescent; and 19 New Bridge-street, Blackfriars, London, E.C.
*Spicer, Thomas Trevetham, M.A., LL.D.*
1864. §Spicer, William R. 19 New Bridge-street, Blackfriars, London, E.C.
1847. *Spiers, Richard James, F.S.A. 14 St. Giles's-street, Oxford.
1864. *Spiller, Captain John, F.C.S. Chemical Department, Royal Arsenal, Woolwich.
1846. *Spottiswoode, William, M.A., V.P.R.S., F.R.A.S., F.R.G.S. (*General Treasurer.*) 50 Grosvenor-place, London, S.W.
1864. *Spottiswoode, W. Hugh. 50 Grosvenor-place, London, S.W.
1854. *Sprague, Thomas Bond. 18 Lincoln's Inn Fields, London.
1853. ‡Spratt, Joseph James. West Parade, Hull.
Square, Joseph Elliot. Plymouth.
*Squire, Lovell. Falmouth.
1859. ‡Stables, William Alexander. Cawdor Castle.
1857. ‡*Stack, Thomas. Dublin.*
1858. *Stainton, Henry T., F.R.S., F.L.S., F.G.S. Mountsfield, Lewisham, Kent.
1851. *Stainton, James Joseph, F.L.S., F.C.S. Horsell, near Ripley, Surrey.
*Stamforth, Rev. Thomas.*
Stanfield, Hamer. Burley, near Otley.
1858. ‡Stanfield, Alfred W. Wakefield.
1865. §Stanford, E. C. C. 1 Holyrood-crescent, Glasgow.
1856. *Stanley, The Right Hon. Lord, M.P., LL.D., F.R.S., F.R.G.S. 23 St. James's-square, London; and Knowsley, Liverpool.
Stanley, The Very Rev. Arthur Penrhyn, D.D., F.R.S., Dean of Westminster. The Deanery, Westminster, London.
Stapleton, H. M. 1 Mountjoy-place, Dublin.
1866. §Starey, Thomas R. Daybrook House, Nottingham.
1850. ‡Stark, James, M.D., F.R.S.E. 21 Rutland-street, Edinburgh.
1863. ‡Stark, Richard M. Hull.
1848. ‡Statham, Henry Joseph. 27 Mortimer-street, Cavendish-sq., London.
Staveley, T. K. Ripon, Yorkshire.
1857. ‡Steel, William Edward, M.D. 15 Hatch-street, Dublin.
1863. §Steele, Rev. Dr. 2 Bathwick-terrace, Bath.
1861. ‡Steinthal, H. M. Hollywood, Fallowfield, near Manchester.
Stenhouse, John, Ph.D. 17 Rodney-street, Pentonville, London, N.

Year of Election.

1863. §Sterriker, John. Driffield.
1861. *Stern, S. J. 33 George-street, Manchester.
§Stevelly, John, LL.D., Professor of Natural Philosophy in Queen's College, Belfast.
1861. *Stevens, Henry, F.S.A., F.R.G.S. 4 Trafalgar-square, London, W.C.
1863. §Stevenson, Archibald. South Shields.
1850. ‡Stevenson, David. 8 Forth-street, Edinburgh.
*Stevenson, Rev. Edward, M.A.*
1863. *Stevenson, James C. South Shields.
1855. Stewart, Balfour, M.A., LL.D., F.R.S., Superintendent of the Kew Observatory of the British Association. Richmond, Surrey.
1864. §Stewart, Charles, F.L.S. 19 Princess Square, Plymouth.
1856. *Stewart, Henry Hutchinson, M.D., M.R.I.A. 71 Eccles-street, Dublin.
1859. ‡Stewart, John. Glasgow.
Stewart, Robert. Glasgow.
1847. ‡Stewart, Robert, M.D. The Asylum, Belfast.
*Stirling, Andrew. Lower Mosley-street, Manchester.
1865. *Stock, Joseph S. Cannon-street, Birmingham.
1849. ‡Stock, T. S. Bourn Brook Hall.
1862. ‡Stockil, William. 5 Church Meadows, Sydenham.
Stoddart, George. 11 Russell-square, London, W.C.
1864. §Stoddart, Walter William, F.G.S. 9 North-street, Bristol.
1854. ‡Stoep, Charles (Consul). 6 Cook-street, Liverpool.
*Stokes, George Gabriel, M.A., D.C.L., Sec. R.S., Lucasian Professor of Mathematics in the University of Cambridge. Pembroke College, Cambridge.
1845. ‡Stokes, Rev. William H., M.A., F.G.S. Cambridge.
1862. ‡Stone, E. J., M.A. Royal Observatory, Greenwich.
1859. ‡Stone, Dr. William H. 13 Vigo-street, London.
1857. ‡Stoney, Bindon B., M.R.I.A. 89 Waterloo-road, Dublin.
1861. *Stoney, George Johnstone, M.A., M.D., F.R.S., M.R.I.A., Secretary to the Queen's University, Ireland. Dublin Castle, Dublin.
1854. ‡Store, George. Prospect House, Fairfield, Liverpool.
1859. §Story, James. 17 Bryanston-square, London, W.
Stowe, William. Buckingham.
Stowell, Rev. H. Acton-square, Salford, Manchester.
Strachan, James M. The Grove, Teddington, Middlesex.
1859. ‡*Strachan, Patrick.*
1863. ‡Strachan, T. Y. Lovaine-crescent, Newcastle-on-Tyne.
1863. ‡Straker, John. Wellington House, Durham.
1850. ‡*Strange, John, LL.D. Edinburgh.*
*Strickland, Arthur. Bridlington Quay, Yorkshire.
*Strickland, Charles. Loughglyn, Ballaghadereen, Ireland.
1845. ‡*Strickland, Henry Eustatius.*
Strickland, J. E. French-park, Roscommon, Ireland.
Strickland, William. French-park, Roscommon, Ireland.
1859. ‡Stronach, William, R.E. Ardmellie, Banff.
1866. *Strutt, The Hon. Arthur. Kingston Hall, near Derby.
1848. ‡Struvé, William Price. Picton-place, Swansea.
*Stroud, Rev. Joseph, M.A.*
*Stuart, Robert. Manchester.*
1854. ‡Stuart, William. 1 Rumford-place, Liverpool.
1861. ‡*Stuart, W. D. Philadelphia.*
1859. ‡*Stuart, William Henry.*
1866. §Stubbins, Henry. Lincoln's-Inn, London, W.C.
1864. ‡Style, Sir Charles, Bart. 102 New Sydney-place, Bath.

Year of Election.

1857. ‡Sullivan, William K., Ph.D., M.R.I.A. Museum of Irish Industry; and 53 Upper Leeson-road, Dublin.
Sutherland, Alexander John, M.D., F.R.S., F.G.S. 6 Richmond-terrace, Westminster, London.
1863. ‡Sutherland, Benjamin John. 10 Oxford-street, Newcastle-on-Tyne.
1862. *Sutherland, George Granville William, Duke of, K.G., F.R.G.S. Stafford House, London.
1855. ‡Sutton, Edwin. 44 Winchester-street, Pimlico, London, S.W.
1863. §Sutton, Francis, F.C.S. Bank Plain, Norwich.
1861. *Swan, Patrick Don S. Kirkaldy, N.B.
1862. *Swan, William, Professor of Natural Philosophy in the University of St. Andrews, N. B.
1863. ‡Swan, William. Walker, Durham.
1853. ‡*Swan, William Thomas.*
1862. *Swann, Rev. S. K. Gedling, near Nottingham.
*Swanwick, J. W.*
Sweetman, Walter, M.A., M.R.I.A. 4 Mountjoy-square North, Dublin.
1863. ‡Swindell, J. S. E. Summerhill, Kingswinford, Dudley.
1863. ‡Swinhoe, Robert, F.R.G.S. Oriental Club, London, W.
1859. ‡Sykes, Alfred. Leeds.
1847. ‡Sykes, H. P. 47 Albion-street, Hyde Park, London, W.
1862. ‡Sykes, Thomas. Cleckheaton, near Leeds.
*Sykes, Colonel William Henry, M.P., F.R.S., Hon. M.R.I.A., F.G.S., F.R.G.S. 47 Albion-street, Hyde Park, London, W.
1847. ‡Sykes, W. H. F. 47 Albion-street, Hyde Park, London.
Sylvester, James Joseph, M.A., LL.D., F.R.S., Professor of Mathematics in the Royal Military Academy, Woolwich. Woolwich; and Athenæum Club, London, S.W.
1850. ‡Syme, James, Professor of Clinical Surgery in the University of Edinburgh. The College, Edinburgh.
1856. *Symonds, Frederick, F.R.C.S. Beaumont-street, Oxford.
1859. ‡Symonds, Captain Thomas Edward, R.N. 10 Adam-street, Adelphi, London, W.C.
1860. ‡Symonds, Rev. W. S., M.A., F.G.S. Pendock Rectory, Worcestershire.
1859. §Symons, G. J. 136 Camden-road, London, W.N.
1855. *Symons, William, F.C.S. 17 St. Mark's-crescent, Regent's Park, London.
Synge, Rev. Alexander. St. Peter's, Ipswich.
Synge, Francis. Glanmore, Ashford, Co. Wicklow.
Synge, John Hatch. Glanmore, Ashford, Co. Wicklow.

1865. §Tailyour, Colonel Renny, R.E. Newmanswalls, Montrose, N. B.
§Talbot, William Hawkshead. Southport, Lancashire.
Talbot, William Henry Fox, M.A., LL.D., F.R.S., F.L.S. Lacock Abbey, near Chippenham.
1866. §Tarbottom, Marrott Ogle, M.I.C.E. Newstead-grove, Nottingham.
Taprell, William. 7 Westbourne-crescent, Hyde Park, London, W.
1861. *Tarratt, Henry W. Bushbury Lodge, Leamington.
1856. ‡Tartt, William Macdonald, F.S.S. Sandford-place, Cheltenham.
1864. ‡Tasker, Rev. J. C. W. 1 Upper Lansdown-villas, Bath.
1857. *Tate, Alexander. 20 Queen-street, Belfast.
1863. ‡Tate, John. Alnmouth, near Alnwick, Northumberland.
1865. ‡Tate, Thomas. Ore, Hastings.
1854. ‡*Tate, Lieut.-Colonel.*
1858. *Tatham, George. Leeds.
1864. *Tawney, Edward. 5 Victoria-square, Clifton, Bristol.
*Tayler, Rev. John James, B.A., Principal and Professor of Ecclesiastical History in Manchester New College, London. 22 Woburn-square, London, W.C.

Year of Election.

Taylor, Frederick. Messrs. Taylor, Potter & Co., Liverpool.
1854. ‡Taylor, Dr. H. R. 1 Percy-street, Liverpool.
*Taylor, James. Culverlands, near Reading.
*Taylor, John, F.G.S. 6 Queen-street-place, Upper Thames-street, London, E.C.
1861. *Taylor, John, jun. 6 Queen-street-place, Upper Thames-st., London.
1856. ‡*Taylor, John.*
1863. ‡Taylor, John. Earsden, Newcastle-on-Tyne.
1863. ‡Taylor, John. Lovaine-place, Newcastle-on-Tyne.
1865. ‡Taylor, Joseph. 99 Constitution-hill, Birmingham.
**Taylor, Vice-Admiral J. N., C.B.*
Taylor, Captain P. Meadows, in the Service of His Highness the Nizam. Harold Cross, Dublin.
*Taylor, Richard, F.G.S. 6 Queen-street-place, Upper Thames-street, London, E.C.
Taylor, Rev. William, F.R.S., F.R.A.S. Thornloe, Worcester.
*Taylor, William Edward. Millfield House, Enfield, near Accrington.
1858. ‡Teale, Joseph. Leeds.
Teale, Thomas Pridgin, F.R.S., F.L.S. 28 Albion-street, Leeds.
1858. ‡Teale, Thomas Pridgin, jun. 20 Park-row, Leeds.
Teather, John. Alstonley, Cumberland.
1865. *Templeton, James. Mansion-house School, St. David's, Exeter.
Tennant, Charles. Glasgow.
1863. ‡Tennant, Henry. Saltwell, Newcastle-on-Tyne.
*Tennant, James, F.G.S., F.R.G.S., Professor of Mineralogy and Geology in King's College, London. 149 Strand, London, W.C.
Tennent, R. J. Belfast.
1857. ‡Tennison, Edward King. Kildare-street Club House, Dublin.
1849. ‡Teschemacher, E. F. Highbury-park North, London, N.
1866. §Thackeray, J. L. Arno Vale, Nottingham.
1850. ‡Thain, Rev. Alexander. New Machar, Aberdeen.
1848. ‡Thirlwall, The Right Rev. Connop, D.D. Abergwili, Carmarthen.
1856. ‡Thodey, Rev. S. Rodborough, Gloucestershire.
*Thom, Rev. David, D.D., Ph.D.*
Thom, John. Messrs. M'Naughton & Co., Moseley-street, Manchester.
Thomas, George. Brislington, Bristol.
1848. **Thomas, George John, M.A.*
1854. ‡*Thompson, Benjamin James.*
1854. ‡*Thompson, D. P., M.D.*
1854. ‡Thompson, Edmund. Claughton Park, Birkenhead.
1863. ‡Thompson, Rev. Francis. St. Giles's, Durham.
1858. *Thompson, Frederick. South Parade, Wakefield.
1859. §Thompson, George, jun. Pidsmedden, Aberdeen.
Thompson, Harry Stephen. Kirby Hall, Great Ouseburn, Yorkshire.
Thompson, Henry Stafford. Fairfield, near York.
1845. ‡Thompson, James. Kirk Houses, Brampton, Cumberland.
1861. *Thompson, Joseph. Woodlands, Wilmslow, near Manchester.
1864. §Thompson, Rev. Joseph Hesselgrave, B.A. Cradley, near Brierley-hill.
Thompson, Leonard. Sheriff-Hutton Park, Yorkshire.
1853. ‡Thompson, Thomas (Austrian Consul). Hull.
Thompson, Thomas (Town Clerk). Hull.
1863. ‡Thompson, William. 11 North-terrace, Newcastle-on-Tyne.
1850. ‡Thomson, Alexander. Banchory House, by Aberdeen.
1855. ‡Thomson, Allen, M.D., Professor of Anatomy. The University, Glasgow.
*Thomson, Corden, M.D. Sheffield.
1852. ‡Thomson, Gordon A. Bedeque House, Belfast.

Year of Election.

Thomson, Guy. Oxford.
1850. ‡Thomson, James. Kendal.
1845. ‡*Thomson, Prof. James, LL.D.*
1855. ‡Thomson, James. 82 West Nile-street, Glasgow.
1850. *Thomson, Professor James, M.A., C.E. 2 Donegal-square West, Belfast.
*Thomson, James Gibson. Edinburgh.
1863. ‡Thomson, M. 8 Meadow-place, Edinburgh.
1865. §Thomson, R. W., C.E., F.R.S.E. Edinburgh.
*Thomson, Thomas.*
1850. ‡Thomson, Thomas, M.D., F.R.S., Superintendent of the Botanic Garden, Calcutta. Hope House, Kew, London.
1847. *Thomson, William, M.A., LL.D., D.C.L., F.R.S. L. & E., Professor of Natural Philosophy in the University of Glasgow. (*Local Treasurer.*) The College, Glasgow.
1850. ‡*Thomson, William Hamilton.*
1850. ‡Thomson, Wyville T. C., LL.D., F.G.S., Professor of Geology in Queen's College, Belfast.
1854. ‡*Thorburn, William, M.D.*
1852. ‡Thorburn, Rev. William Reid, M.A. Starkies, Bury, Lancashire.
1866. §Thornton, James. Edwalton, Nottingham.
*Thornton, Samuel. The Elms, Camp-hill, Birmingham.
1865. *Thornley, S. Sparkbrook, Birmingham.
1845. ‡Thorp, Dr. Disney. Suffolk Laun, Cheltenham.
*Thorp, The Venerable Thomas, B.D., F.G.S., Archdeacon of Bristol. Kemerton, near Tewkesbury.
1864. §Thorp, William, jun., F.C.S. 401 Kingsland-road, London, N.E.
Thurnam, John, M.D. Devizes.
1856. ‡Tibbs, Somerset. 58 Regent-street, Cheltenham.
1865. §Timmins, Samuel. Elvetham-road, Edgbaston, Birmingham.
Tinker, Ebenezer. Mealhill, near Huddersfield.
*Tinné, John A., F.R.G.S. Briarly Aigburth, Liverpool.
1846. ‡*Tipper, S.*
Tite, William, M.P., F.R.S., F.G.S., F.S.A. 42 Lowndes-square, London, S.W.
Tobin, Rev. John. Liscard, Cheshire.
1850. ‡Tod, James, Sec. Soc. of Arts. Edinburgh.
Todd, Rev. James Henthorn, D.D., M.R.I.A. Trinity College, Dublin.
1859. ‡Todd, Thomas. Mary Culter House, Aberdeen.
1861. *Todhunter, Isaac, M.A., F.R.S. St. John's College, Cambridge.
Todhunter, J. 3 College Green, Dublin.
1857. ‡Tombe, Rev. H. J. Ballyfree, Ashford, Co. Wicklow.
1856. ‡Tomes, Robert Fisher. Welford, Stratford-on-Avon.
1866. §Tomlin, J. R. Stoke Field, Newark.
1864. *Tomlinson, Charles, F.R.S., F.C.S. King's College, London, W.C.: and Highgate, London, N.
1863. ‡Tone, John F. Jesmond Villas, Newcastle-on-Tyne.
1865. §Tonks, Edmund B. C. L. Packwood Grange, Knowle, Warwickshire.
1865. §Tonks, William. 4 Carpenter-road, Edgbaston, Birmingham.
1865. §Tonks, William Henry. 4 Carpenter-road, Edgbaston, Birmingham.
1861. *Topham, John, A.I.C.E. 49 Shrubland Grove East, Dalston, London, N.E.
1863. ‡Torr, F. S. 38 Bedford-row, London.
1863. ‡Torrens, R. R. 2 Gloucester-place, Hyde Park, London, W.
Torrie, Thomas Jameson. Edinburgh.
1859. ‡Torry, Very Rev. John, Dean of St. Andrews. Coupar Angus, N.B.
Towgood, Edward. St. Neots, Huntingdonshire.

Year of Election.

*Townend, John.*
*Townend, Thomas.*
*Townend, T. S.*
1860. ‡Townsend, John. 11 Burlington-street, Bath.
1857. ‡Townsend, Rev. Richard, M.A. Trinity College, Dublin.
1861. §Townsend, William. Attleborough Hall, near Nuneaton.
1854. ‡Towson, John Thomas. 47 Upper Parliament-street, Liverpool; and Local Marine Board, Liverpool.
1859. ‡Trail, Rev. Robert, M.A. Boyndie, Banff.
1859. ‡Trail, Samuel, LL.D., D.D. The Manse, Hanay, Orkney.
1850. ‡Traill, Professor, M.D. Edinburgh.
*Travers, Robert, M.B.*
1865. ‡Travers, William, F.R.C.S. 1 Bath-place, Kensington, London, W.
1851. ‡Travis, W. H. Whitton, near Ipswich.
1859. ‡Trefusis, The Hon. C., M.P. Heaton, Devonshire.
Tregelles, Nathaniel. Neath Abbey, Glamorganshire.
Trench, F. A. Newlands House, Clondalkin, Ireland.
*Trevelyan, Arthur. Wallington, Newcastle-on-Tyne.
Trevelyan, Sir Walter Calverley, Bart., M.A., F.R.S.E., F.G.S., F.S.A., F.R.G.S. Wallington, Northumberland; and Nettlecombe, Somerset.
1860. §Tristram, Rev. H. B., M.A., F.L.S. Greatham Hospital, near Stockton-on-Tees.
1864. ‡Truell, Robert. Ballyhenry, Ashford, Co. Wicklow.
Tuckett, Francis. Frenchay, near Bristol.
1847. *Tuckett, Francis Fox. Frenchay, near Bristol.
Tuckett, Frederick. 4 Mortimer-street, Cavendish-square, London.
Tuckett, Henry. Frenchay, near Bristol.
1848. ‡*Tudor, Edward Scripp.*
Tuke, J. H. Bank, Hitchen.
Tuke, Samuel. Lawrence-street, York.
1865. §Turberville, H. Pilton, Barnstaple.
1854. ‡Turnbull, James, M.D. 86 Rodney-street, Liverpool.
1855. §Turnbull, John. 276 George-street, Glasgow.
1856. ‡Turnbull, Rev. J. C. 8 Bays-hill Villas, Cheltenham.
*Turnbull, Rev. Thomas Smith, M.A., F.R.S., F.R.G.S. Blofield, Norfolk.
1861. *Turner, James Aspinal. Pendlebury, near Manchester.
Turner, Thomas, M.D. 31 Curzon-street, May Fair, London, W.
1863. §Turner, William, M.B., F.R.S.E. The University, Edinburgh.
1854. §Tuton, Edward S. Holy Bank, Laurel-road, Fairfield, Liverpool.
1842. Twamley, Charles, F.G.S. 6 Queen's-road, Gloucester Gate, Regent's Park, London.
1859. ‡Twining, H. R. Grove Lodge, Clapham, London.
1847. ‡Twining, Richard. 13 Bedford-place, Russell-square.
1847. ‡Twiss, Travers, D.C.L., F.R.S., F.R.G.S., Regius Professor of Civil Law in the University of Oxford, and Chancellor of the Diocese of London. 19 Park-lane, London.
1846. ‡Tylor, Alfred, F.G.S., F.L.S. Warwick-lane, London.
1865. §Tylor, Edward Burnett. Lindon, Wellington, Somerset.
1858. *Tyndall, John, LL.D., Ph.D., F.R.S., F.C.P.S., Professor of Natural Philosophy in the Royal Institution and Royal School of Mines. Royal Institution, Albemarle-street, London, W.
Tyrrell, John. Exeter.
1861. *Tysoe, John. Sedgley-road, Pendleton, near Manchester.

*Upton, Rev. James Samuel, M.A., F.G.S.*
1855. ‡Ure, John. 114 Montrose-street, Glasgow.

Year of Election.

1859. ‡Urquhart, Rev. Alexander. Tarbat, Ross-shire.
1859. ‡Urquhart, W. Pollard. Craigston Castle, N. B.; and Castlepollard, Ireland.
1866. §Urquhart, William W. Nursery House, Dundee.

*Vallack, Rev. Benj. W. S. St. Budeaux, near Plymouth.
1854. ‡Vale, James Theodorick. Hamilton-square, Birkenhead.
*Vance, Rev. Robert. 16 Montpellier-hill, Dublin.
1863. ‡Vandoni, le Commandeur Comte de, Chargé d'Affaires de S. M. Tunisienne, Geneva.
1853. §Varley, Cornelius. 337 Kentish Town-road, London, N.W.
1854. ‡*Varley, Cromwell F.*
1865. *Varley, S. Alfred. 66 Roman-road, Holloway, London, N.
1863. ‡Vauvert, de Mean A., Vice-Consul for France. Tynemouth.
1849. *Vaux, Frederick. Central Telegraph Office, Adelaide, South Australia.
Vavasour, Sir Henry Mervun, Bart.
*Veitch, A. J., M.D.*
Verney, Sir Harry, Bart. Lower Claydon, Bucks.
1866. §Vernon, Rev. E. H. Harcourt. Cotgrave Rectory, near Nottingham.
Vernon, George John, Lord. 32 Curzon-street, London; and Sudbury Hall, Derbyshire.
1854. *Vernon, George V., F.R.A.S. Piccadilly Mills; and Old Trafford, Manchester.
1854. *Vernon, John. High Lee, Woolton, Liverpool.
Veysie, Rev. Daniel, B.D. Daventry.
1864. *Vicary, William, F.G.S. The Priory, Colleston, Exeter.
1859. ‡*Vickers, Thomas.*
1854. *Vignoles, Charles, C.E., F.R.S., M.R.I.A., F.R.A.S. 21 Duke-street, Wsetminster, London,
Visger, Herman. Frenchay, Bristol.
1856. ‡Vivian, Rev. Edward, B.A. Woodfield, Torquay.
*Vivian, H. Hussey, M.P., F.G.S. 5 Upper Belgrave-street, London; and Singleton House, Swansea.
1856. §Voelcker, J. Ch. Augustus, Ph.D., F.C.S. 39 Argyll-road, Kensington, London, W.
*Voelker, Professor Charles. Switzerland.*
Vye, Nathaniel. Ilfracombe, Devon.

1860. §Waddingham, John. Guiting Grange, Winchcombe, Gloucestershire.
1859. ‡Waddington, John. New Dock Works, Leeds.
1855. *Waldegrave, The Hon. Granville. 26 Portland-place, London, W.
1863. ‡Walker, Alfred O. City of Chester.
1849. §Walker, Charles V., F.R.S., F.R.A.S. Fernside Villa, Redhill, near Reigate.
Walker, Sir Edward S. Berry Hill, Mansfield.
Walker, Francis, F.L.S., F.G.S. Rectory House, The Grove, Highgate.
*Walker, Frederick John.*
1859. ‡Walker, James. 16 Norfolk-crescent, London, W.
1855. ‡Walker, John. 1 Exchange-court, Glasgow.
1842. *Walker, John. Thorncliffe, Leamington.
1855. ‡Walker, John James, M.A. 2 Trinity College, Dublin.
*Walker, Joseph N., F.L.S. Caldeston, near Liverpool.
1866. *Walker, J. F. Sidney College, Cambridge.
1866. §Walker, S. D. 38 Hampden-street, Nottingham.
*Walker, Thomas. 10 York-street, Manchester.
1866. §Walker, H. Westwood, Fifeshire.
Walker, William. 47 Northumberland-street, Edinburgh.

Year of Election.

Wall, Rev. R. H., M.A. 6 Hume-street, Dublin.
1863. §Wallace, Alfred R., F.R.G.S. 9 Mark's-crescent, Regent's-park, London, N.W.
1859. ‡Wallace, William, Ph.D., F.C.S. Chemical Laboratory, 3 Bath-street, Glasgow.
1856. ‡Waller, Augustus V., M.D., F.R.S. Bruges.
1857. ‡Waller, Edward. Lisenderry, Aughnacloy, Ireland.
1862. ‡Wallich, George Charles, M.D., F.L.S. 11 Earls-terrace, Kensington, London, W.
Wallinger, Rev. William. Hastings.
Walmesley, Sir Joshua, Knt. Liverpool.
Walmesley, Joshua. Lord-street, Liverpool.
1862. §Walpole, The Right Hon. Spencer Horatio, M.A., D.C.L., M.P., F.R.S. Ealing, near London.
1857. ‡Walsh, Albert Jasper. 89 Harcourt-street, Dublin.
Walsh, John (Prussian Consul). 1 Sir John's Quay, Dublin.
1863. ‡Walters, Robert. Eldon-square, Newcastle-on-Tyne.
Walton, Thomas Todd. Clifton, Bristol.
1863. §Wanklyn, James Alfred, F.R.S.E., F.C.S. London Institution, Finsbury-circus, London, E.C.
Wansey, William, F.S.A. Reform Club, Pall Mall.
1857. ‡Ward, John S. Prospect-hill, Lisburn, Ireland.
1847. ‡Ward, Nathaniel Bagshaw, F.R.S., F.L.S. 14 Clapham Rise, London, S.
Ward, Rev. Richard, M.A. 12 Eaton-place, London, S.W.
1863. ‡Ward, Robert. Dean-street, Newcastle-on-Tyne.
*Ward, William Sykes, F.C.S. Denison Hall, Leeds.
Wardell, William. Chester.
1858. ‡Wardle, Thomas. Leek Brook, Leek, Staffordshire.
‡Warington, Robert, F.R.S., F.C.S., Chemical Operator to the Society of Apothecaries. Apothecaries' Hall, London, E.C.
1865. §Waring, Dr. E. J. 28 George-street, Hanover-square, London, W.
1864. *Warner, Edwin. Higham Hall, Woodford, Essex.
1856. ‡Warner, Thomas H. Lee. Tiberton Court, Hereford.
1865. *Warren, Edward P., L.D.S. 13 Old-square, Birmingham.
Warwick, William Atkinson. Wyddrington House, Cheltenham.
1856. ‡Washbourne, Buchanan, M.D. Gloucester.
1847. ‡Waterhouse, G. R. British Museum, London, W.C.
*Waterhouse, John, F.R.S., F.G.S., F.R.A.S. Wellhead, Halifax, Yorkshire.
1854. ‡Waterhouse Nicholas. 5 Rake-lane, Liverpool.
1854. ‡Watkins, James. Bolton.
1855. ‡Watson, Ebenezer. 16 Abercromby-place, Glasgow.
*Watson, Henry Hough, F.C.S. The Folds, Bolton-le-Moors.
Watson, Hewett Cottrell, F.L.S. Thames Ditton, Surrey.
Watson, James. Glasgow.
1855. ‡Watson, James, M.D. 152 St. Vincent-street, Glasgow.
1863. ‡Watson, Joseph. Bensham Grove, near Gateshead-on-Tyne.
1859. ‡Watson, J. Forbes. India Office, London, S.W.
1863. §Watson, R. S. 101 Pilgrim-street, Newcastle-on-Tyne.
1858. ‡Watson, William. Bilton House, Harrogate.
*Watson, William H.*
1855. ‡Watt, George. West Regent-street, Glasgow.
1861. ‡Watts, Sir James. Abney Hall, Cheadle, near Manchester.
1846. §Watts, John King, F.R.G.S. St. Ives, Huntingdonshire.
1858. ‡Waud, Major E. Manston Hall, near Leeds.
Waud, Rev. S. W., M.A., F.R.A.S., F.C.P.S. Rettenden, near Wickford, Essex.

Year of Election.

1862. §Waugh, Major-General Sir Andrew Scott, R.E., F.R.S., F.R.G.S., late Surveyor-General of India, and Superintendent of the Great Trigonometrical Survey. 7 Petersham-terrace, Queen's Gate, London, W.
1859. ‡Waugh, Edwin. Sager-street, Manchester.
*Way, J. Thomas, F.C.S., Professor of Chemistry, Royal Agricultural Society of England. 72 Victoria-street, Westminster, London.
Webb, Rev. John, M.A., F.S.A. Hardwick Parsonage, Hay, South Wales.
*Webb, Rev. Thomas William, M.A., F.R.A.S. Hardwick Parsonage, Hay, South Wales.
1866. *Webb, W. F. Newstead Abbey, Nottingham.
1856. ‡Webster, James. Hatherley Court, Cheltenham.
1859. ‡Webster, John. 42 King-street, Aberdeen.
1858. ‡Webster, John. Broomhall Park; and St. James's-row, Sheffield.
1862. ‡Webster, John Henry, M.D. Northampton.
1864. §Webster, John. Sneinton, Nottingham.
Webster, Thomas, M.A., F.R.S. 2 Great George-street, Westminster, London.
1853. ‡Weddell, Thomas. Scarborough.
1845. ‡Wedgewood, Hensleigh. 17 Cumberland-terrace, Regent's Park, London, N.W.
1854. ‡Weightman, William Henry. Litherland, Liverpool.
1865. §Welch, Christopher, M.A. University Club, Pall Mall East, London, S.W.
1850. ‡*Welsh, John.*
1850. ‡Wemyss, Alexander Watson, M.D. St. Andrews, N.B.
1850. ‡Wemyss, William. 6 Salisbury-road, Edinburgh.
Wentworth, Frederick W. T. Vernon. Wentworth Castle, near Barnsley, Yorkshire.
1864. *Were, Anthony Berwick. Wigton, Cumberland.
1865. §Wesley, William Henry. 31 Clayland-road, Clapham, London, S.
1853. ‡West, Alfred. Holderness-road, Hull.
1858. ‡West, F. H. Chapel Allerton, near Leeds.
1853. ‡West, Leonard. Summergangs Cottage, Hull.
1853. ‡West, Stephen. Hessle Grange, near Hull.
*Westcott, Jasper.*
1851. ‡Western, Thomas Burch. Tattingstone House, Ipswich.
1851. *Western, Sir T. B., Bart., M.P. Felix Hall, Kelvedon, Essex.
1842. Westhead, Edward. Chorlton-on-Medlock, near Manchester.
Westhead, John. Manchester.
1842. *Westhead, Joshua Proctor. York House, Manchester.
1851. ‡Westhorpe, Stirling. Tower-street, Ipswich.
1857. *Westley, William. 24 Regent-street, London, S.W.
1863. ‡Westmacott, Percy. Whickham, Gateshead, Durham.
1860. §Weston, James Woods. Seedley House, Pendleton, Manchester.
1858. ‡*Weston, William. Birkenhead.*
1864. §Westropp, W. H. S., F.R.G.S.I. 2 Idrone-terrace, Blackrock, Dublin.
1860. ‡Westwood, John O., M.A., F.L.S. Henley House, Summertown, Oxon.
Wharton, W. L., M.A. Dryburn, Durham.
1849. ‡Whateley, George. Birmingham.
1853. ‡Wheatley, E. B. Cote Wall, Merfield, Yorkshire.
Wheatstone, Charles, D.C.L., F.R.S., Hon. M.R.I.A., Professor of Experimental Philosophy in King's College, London. 19 Park-crescent, Regent's Park, London, N.W.
1866. §Wheatstone, Charles C. 19 Park-crescent, Regent's Park, London.

Year of Election.

1847. ‡Wheeler, Edmund, F.R.A.S. 48 Tollington-road, Holloway, London.
1853. ‡Whitaker, Charles J. P. Milton Hill, near Hull.
1859. *Whitaker, William, B.A., F.G.S. Geological Survey Office, 28 Jermyn-street, London, S.W.
1866. §White, Charles, F.R.G.S. Barnesfield House, near Dartford, Kent.
1864. §White, Edmund. New Bond-street, Bath.
White, John. 80 Wilson-street, Glasgow.
1859. ‡White, John Forbes. 16 Bon Accord-square, Aberdeen.
1865. §White, Joseph. Regent's-street, Nottingham.
1859. ‡White, Thomas Henry. Tandragee, Ireland.
1861. ‡Whitehead, James, M.D. 87 Mosley-street, Manchester.
1854. ‡Whitehead, James W. 15 Duke-street, Edge-hill, Liverpool.
1858. ‡Whitehead, J. H. Southsyde, Saddleworth.
1861. *Whitehead, J. B. Oakley-terrace, Rawtenstall, Manchester.
1861. *Whitehead, Peter Ormerod. Belmont, Rawtenstall, Manchester.
1855. * *Whitehouse, Wildman.*
*Whitehouse, William.* 10 Queen-street, Rhyl.
*Whiteside, James, M.A., Lord Chief Justice of Ireland. 2 Mountjoy-square, Dublin.
1866. §Whitfield, Samuel. Golden Hillock, Small Heath, Birmingham.
1861. ‡Whitford, J. Grecian-terrace, Harrington, Cumberland.
1852. ‡Whitla, Valentine. Beneden, Belfast.
Whitley, Rev. Charles Thomas, M.A., F.R.A.S., Reader in Natural Philosophy in the University of Durham. Bedlington, Morpeth.
1865. ‡Whittern, James Sibley. Wyken Colliery, Coventry.
1857. *Whitty, John Irwine, M.A., D.C.L., LL.D., Civil Engineer. Ricketstown Hall, Carlow.
1863. *Whitwell, Thomas. Stockton-on-Tees.
*Whitworth, Joseph, LL.D., F.R.S. The Firs, Manchester; and Stancliffe Hall, Derbyshire.
1857. ‡Widdup, —. Penzance; and Kilburn, Co. Wexford.
1865. ‡Wiggin, Henry. Metchley Grange, Harbourne, Birmingham.
1863. ‡ *Wigham, John. Dublin.*
1852. ‡Wigham, Robert. Norwich.
1854. ‡Wight, Robert, M.D., F.R.S., F.L.S. Grazeley Lodge, Reading.
1860. ‡Wilde, Henry. 2 St. Ann's-place, Manchester.
1852. ‡Wilde, Sir William Robert, M.D., M.R.I.A. 1 Merrion-square North, Dublin.
Wilderspin, Samuel. Wakefield.
1855. ‡Wilkie, John. 46 George-square, Glasgow.
1861. *Wilkinson, Eason, M.D. Greenheys, Manchester.
1857. ‡Wilkinson, George. Monkstown, Ireland.
1859. §Wilkinson, Robert. Totteridge Park, Herts.
*Willan, William.*
*Willert, Paul Ferdinand. Manchester.
1859. ‡Willet, John, C.E. 35 Albyn-place, Aberdeen.
*Williams, Caleb, M.D. Micklegate, York.
Williams, Charles James B., M.D., F.R.S., Professor of Medicine in University College, London. 49 Upper Brook-street, Grosvenor-square, London, W.
1861. *Williams, Charles Theodore, B.A. 40 Upper Brook-street, London.
1864. *Williams, Frederick M., M.P., F.G.S. Goonvrea, Perranarworthal, Cornwall.
1861. *Williams, Harry Samuel. 49 Upper Brook-street, Grosvenor-square, London, W.
1857. ‡Williams, Rev. James. Llanfairinghornwy, Holyhead.
Williams, Richard. 38 Dame-street, Dublin.
Williams, Robert, M.A. Bridehead, Dorset.

Year of Election.

1861. ‡Williams, R. Price. 22 Ardwick Green, Manchester.
Williams, Walter. St. Alban's House, Edgbaston, Birmingham.
1854. ‡*Williams, William.*
*Williams, William. Highbury-crescent, London, N.
1865. ‡Williams, William M. The Celyn, Caergwele, near Wrexham.
1850. *Williamson, Alexander William, Ph.D., F.R.S., F.C.S., Professor of Chemistry, and of Practical Chemistry, University College, London. 12 Fellows-road, Haverstock-hill, London, N.W.
1857. ‡Williamson, Benjamin. Trinity College, Dublin.
1863. ‡Williamson, John. South Shields.
*Williamson, Rev. William, B.D. Datchworth, Welwyn, Hertfordshire.
*Williamson, W. C. Manchester.*
Willis, Rev. Robert, M.A., F.R.S., Jacksonian Professor of Natural and Experimental Philosophy in the University of Cambridge. 23 York-terrace, Regent's Park, London, N.W.; and Cambridge.
1865. *Willmott, Henry. Mona House, Handsworth, Birmingham.
1857. ‡Willock, Rev. W. N., D.D. Cleenish, Enniskillen, Ireland.
1850. *Wills, Alfred. 4 Harcourt-buildings, Inner Temple, London, E.C.
1865. ‡Wills, Arthur W. Edgbaston, Birmingham.
Wills, W. R. Edgbaston, Birmingham.
*Wilson, Alexander, F.R.S. 34 Bryanston-square, London, W.
1859. §Wilson, Alexander Stephen, C.E. North Kinmundy, Summerhill, by Aberdeen.
1850. ‡Wilson, Dr. Daniel. Toronto, Upper Canada.
1863. ‡Wilson, Frederic R. Alnwick, Northumberland.
1847. *Wilson, F. Leamington.
1863. §Wilson, George. Hawick.
1861. ‡Wilson, George Daniel. 24 Ardwick Green, Manchester.
1855. ‡Wilson, Hugh. 75 Glassford-street, Glasgow.
1847. ‡Wilson, James Hewetson. The Grange, Worth, Sussex.
1857. ‡Wilson, James Moncrieff. 9 College Green, Dublin.
1858. *Wilson, John. Seacroft, near Leeds.
*Wilson, John. Bootham, York.
1855. *Wilson, John, jun. West Hurlet, near Glasgow.
1865. §Wilson, J. M., M.A. Rugby.
Wilson, Professor John, F.G.S., F.R.S.E. Museum, Jermyn-street, London, S.W.
1847. *Wilson, Rev. Sumner. Preston Candover, Micheldever Station.
*Wilson, Thomas, M.A. Crimbles House, Leeds.
1859. ‡Wilson, Thomas. Tunbridge Wells.
1863. *Wilson, Thomas. Shotley Hall, Gateshead, Durham.
1861. ‡Wilson, Thomas Bright. 24 Ardwick Green, Manchester.
1847. *Wilson, William Parkinson, M.A., Professor of Pure and Applied Mathematics in the University of Melbourne.
1861. ‡Wiltshire, Rev. Thomas, M.A., F.G.S., F.R.A.S. Rectory, Bread-street-hill, London, E.C.
1846. ‡Winchester, The Marquis of. Amport House, Andover.
1866. *Windley, W. Mapperley, Nottingham.
1855. ‡*Wingate, Major H. Glasgow.*
*Winsor, F. A. 60 Lincoln's Inn Fields, London, W.C.
1854. ‡*Winter, Thomas.*
1863. *Winwood, Rev. H. H., M.A., F.G.S. 4 Cavendish-crescent, Bath.
1848. ‡Wise, Rev. Stainton, M.D. Banbury.
1856. ‡Witts, Rev. E. F. Upper Slaughter, Cheltenham.
*Wollaston, Thomas Vernon, M.A., F.L.S. Barnpark-terrace, Teignmouth.
1850. ‡Wood, Alexander, F.R.C.P. Edinburgh.

[illegible]

[illegible] *W[illegible] [illegible] Barwick Hall, Bishop Auckland.
[illegible] *W[illegible] [illegible], F.G.S. Richmond, Yorkshire.
[illegible] *W[illegible] [illegible] Ormerod Hall, Chorley, Lancashire.
[illegible] W[illegible] [illegible], M.A.
[illegible] *W[illegible] [illegible], M.D. Philadelphia, United States.
[illegible] *W[illegible] Rev. [illegible], M.A., F.G.S. Holwell Rectory, Sherborne, Dorset.
*W[illegible] [illegible]. St. Saviour Gate, York.
W[illegible] [illegible], M.D.
[illegible] W[illegible] [illegible], M.D. Driffield, Yorkshire.
[illegible] W[illegible] [illegible], F.S.A., F.G.S. St. Mary's Court, Shrewsbury.
[illegible] W[illegible] [illegible], Esq. Fife.
W[illegible] [illegible]. Birmingham-street, Liverpool.
*W[illegible] [illegible]. Monastic House, Pontefract.
*W[illegible] [illegible], M.D. 34 Upper Harley-street, London, W.
[illegible] W[illegible] [illegible]. Simetum Lodge, near Manchester.
*W[illegible] Rev. [illegible] Spicer, M.A. Oakham, Rutlandshire.
*W[illegible] Major [illegible], M.A., F.G.S. St. Nicholas House, Scarborough.
[illegible] *W[illegible] [illegible], F.G.S. Ealing, Hampstead, London, N.W.
*W[illegible] [illegible]. Manchester, near Manchester.
[illegible] W[illegible] [illegible]. Edgbaston House, Edgbaston, Birmingham.
[illegible] *W[illegible] [illegible], C.E. 11 Great George-street, Westminster, London.
*W[illegible] [illegible]. Worcester-crescent, Hyde Park, London W.
W[illegible] [illegible]. Chancery Buildings, Angel-court, London, E.C.
[illegible] *W[illegible] [illegible], F.G.S. British Museum, London, W.C.
W[illegible] [illegible], F.R.A.S. Lewes, Sussex.
W[illegible] [illegible]. Stalybridge, Manchester.
[illegible] *W[illegible] Rev. [illegible], LL.B. Her Majesty's Dockyard, Portsmouth.
[illegible] §W[illegible] [illegible] Sutton, jun. South Collingham, Newark.
[illegible] [illegible]
*W[illegible] [illegible]. 33 Belsize-road, St. John's Wood, London, N.W.
[illegible] *W[illegible] [illegible]. Clarrington-place, Clifton, Bristol.
[illegible] [illegible], Samuel. Bristol.
[illegible] *W[illegible] Rev. Alfred Williams, B.A. Mansfield.
W[illegible] Archibald. Whitchurch, Salop.
W[illegible] James. Polygon, Ardwick, Manchester.
[illegible] *W[illegible] Robert. Ardwick, Manchester.
W[illegible] William. Brockhurst Hall, Northwich, Cheshire.
1856. §Worthy, George S. 130 Vine-street, Liverpool.
W[illegible] John. 6 Suffolk-place, Pall Mall, London, S.W.
1857. §Wright, Edward. 43 Dame-street, Dublin.
1861. *Wright, E. Abbot. Castle Park, Frodsham, Cheshire.
1867. §Wright, E. Perceval, A.M., M.D., F.L.S., M.R.I.A., Professor of Zoology, and Director of the Museum, Dublin University. 10 Clare-street, Dublin.
1868. §Wright, G. H. Mapperley, Nottingham.
1858. ‡Wright, Henry. Stafford House, London, S.W.
*Wright, John.*
Wright, J. Robinson, C.E. 11 Duke-street, Westminster.
1865. ‡Wright, J. S. 168 Bromley-street West, Birmingham.
*Wright, Robert Francis. Hinton Blewett, Somersetshire.
1865. §Wright, Thomas, F.S.A. 14 Sydney-street, Brompton, London, S.W.
Wright, T. G., M.D. Wakefield.
1865. ‡Wrightson, Francis, Ph.D. Ivy House, Kingsmorton.
Wrottesley, John, The Rt. Hon. Lord, M.A., D.C.L., F.R.S., F.R.A.S. Wrottesley Hall, Wolverhampton.
1866. §Wyatt, James, F.G.S. Bedford.

Year of Election.

Wyld, James, M.P., F.R.G.S. Charing Cross, London, W.C.
1863. *Wyley, Andrew. Drumadarragh, Doagh, Belfast.
1845. † *Wylie, John, M.D. Madras Army.*
1862. †Wynne, Arthur Beevor, F.G.S., of the Geological Survey of India. 5 Well-street, Jermyn-street, London, S.W.

*Yarborough, George Cook. Camp's Mount, Doncaster.
1857. † *Yates, Edward.*
1865. † *Yates, Edwin.*
1865. §Yates, Henry. Emscote Villa, Aston Manor, Birmingham.
Yates, James. Carr House, Rotherham, Yorkshire.
Yates, James, M.A., F.R.S., F.G.S., F.L.S. Lauderdale House, Highgate, London, N.
1845. †Yates, John Aston. 53 Bryanston-square, London, W.
1855. †Yeats, John, LL.D., F.R.G.S. Leicester House, Peckham, London, S.E.
*Yorke, Colonel Philip, F.R.S., F.R.G.S. 89 Eaton-place, Belgrave-square, London, S.W.
Young, James. South Shields.
Young, James. Limefield, West Calden, Midlothian.
Young, John. Taunton, Somersetshire.
1858. †Young, John. Hope Villa, Woodhouse-lane, Leeds.
Young, Thomas. North Shields.
Younge, Robert, F.L.S. Greystones, near Sheffield.
*Younge, Robert, M.D. Greystones, near Sheffield.
1865. †Younghusband, Major-General. Ellom House, Charlton-road, Cheltenham.

1854. †Zwilchenburt, Emanuel. 3 Romford-street, Liverpool.

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Louis Agassiz, M.D., Ph.D., Professor of Natural History. Cambridge, U.S.
1852. M. Babinet. Paris.
1857. Dr. Barth.
1866. Captain L. Belavenetz, R.I.N., F.R.I.G.S., M.S.C.M.A., Superintendent of the Compass Observatory, Cronstadt, Russia.
1861. Dr. Bergsma, Director of the Magnetic Survey of the Indian Archipelago. Utrecht, Holland.
1857. Professor Dr. T. Bolzani. Kasan, Russia.
1852. Mr. G. P. Bond. Observatory, Cambridge, U.S.
1846. M. Boutigny (d'Evreux).
1842. Professor Braschman. Moscow.
1864. Dr. H. D. Buys-Ballot, Superintendent of the Royal Meteorological Institute of the Netherlands. Utrecht, Holland.
1861. Dr. Carus. Leipzig.
1864. M. Des Cloizeaux. Paris.
1855. Dr. Ferdinand Cohn. Breslau, Prussia.
1866. Geheimrath von Dechen. Bonn.
1862. Wilhelm Delffs, Professor of Chemistry in the University of Heidelberg.
1845. Heinrich Dove, Professor of Natural Philosophy in the University of Berlin.
Professor Dumas. Paris.
Professor Christian Gottfried Ehrenberg, M.D., Secretary of the Royal Academy, Berlin.
1846. Dr. Eisenlohr. Carlsruhe, Baden.
1842. Dr. A. Erman. Berlin.
1848. Professor Esmark. Christiania.
1861. Professor A. Favre. Geneva.
1855. M. Léon Foucault. Paris.
1856. Professor E. Frémy. Paris.
1842. M. Frisiani. Milan.
1866. Dr. Gaudry, Pres. Geol. Soc. of France. Paris.
1861. Dr. Geinitz, Professor of Mineralogy and Geology. Dresden.
1852. Professor Asa Gray. Cambridge, U.S.
1866. Professor Edward Grube, Ph.D.
1862. Dr. D. Bierens de Haan, Member of the Royal Academy of Sciences, Amsterdam. Leiden, Holland.
Professor Henry. Washington, U.S.
1864. Professor E. Hébert. The Sorbonne, Paris.
1861. Dr. Hochstetter. Vienna.
1848. Dr. Van der Hoeven. Leyden.
1842. M. Jacobi. St. Petersburg.
1867. Janssen, Dr. Paris.
1862. Charles Jessen, Med. et Phil. Dr., Professor of Botany in the University of Greifswald, and Lecturer of Natural History, and Librarian at the Royal Agricultural Academy, Eldena, Prussia.

Year of Election.

1866. Dr. Henry Kiepert, Professor of Geography. Berlin.
1862. Aug. Kekulé, Professor of Chemistry. Ghent, Belgium.
1861. M. Khanikof. 97 Rue de Lille, Paris.
1856. Professor A. Kölliker. Wurzburg, Bavaria.
1856. Laurent-Guillaume De Koninck, M.D., Professor of Chemistry and Palæontology in the University of Liége, Belgium.
1845. Dr. A. Kupffer. St. Petersburg.
Dr. Lamont. Munich.
Baron von Liebig. Munich.
1862. Professor A. Escher von der Linth. Zurich, Switzerland.
1857. Professor Loomis. New York.
1850. Professor Gustav Magnus. Berlin.
1847. Professor Matteucci. Pisa, Tuscany.
1862. Professor P. Merian. Bâle, Switzerland.
1846. Professor von Middendorff. St. Petersburg.
1848. Dr. J. Milne-Edwards. Paris.
1855. M. l'Abbé Moigno. Paris.
1864. Dr. Arnold Moritz. Tiflis, Russia.
1856. W. Morren, Professeur de Botanique à l'Université de Liége, Belgium.
1866. Chevalier C. Negri. Florence, Italy.
1864. Herr Neumayer. Munich.
1848. Professor Nilsson. Sweden.
1856. M. E. Peligot, Memb. de l'Institut, Paris.
1861. Professor Benjamin Pierce. Cambridge, U.S.
1857. Gustav Plaar. Strasburg, France.
1849. Professor Plücker. Bonn, Prussia.
1852. M. Constant Prévost. Paris.
M. Quetelet. Brussels.
M. De la Rive. Geneva.
1866. Dr. F. Römer, Professor of Geology. Berlin.
1850. Professor W. B. Rogers. Boston, U.S.
1857. Herman Schlagintweit. Berlin.
1857. Robert Schlagintweit. Berlin.
1861. M. Werner Siemens. Berlin.
1849. Dr. Siljestrom. Stockholm.
1862. J. A. de Souza, Professor of Physics in the University of Coimbra, Portugal.
1864. Adolph Steen, Professor of Mathematics, Copenhagen.
1866. Professor Steenstrup. Copenhagen.
1845. Dr. Svanberg. Stockholm.
1852. M. Pierre Tchihatchef.
1864. Dr. Otto Torell. University of Lund, Sweden.
1864. Professor A. Vambery. Hungary.
1861. Professor E. Verdet. Paris.
1861. M. de Verneuil, Memb. de l'Institut, Paris.
1848. M. Le Verrier. Paris.
Baron Sartorius von Waltershausen. Göttingen, Hanover.
1842. Professor Wartmann. Geneva.
1864. Dr. Frederick Welwitsch. Lisbon.

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